TRANSFORMING AIRBORNE COMMAND and CONTROL and INTELLIGENCE, SURVEILLANCE, AND RECONNAISSANCE

BY

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DISCLAIMER

ABOUT THE AUTHOR

Major Kouji Gillis was commissioned through the Reserve Officer Training Corps, University of Central Florida in 1997 with a Bachelor of Science in Business Administration. He also earned a Master of Aeronautical Science in Aviation Management from Embry Riddle Aeronautical University and Master of Arts in National Security Affairs from the Naval Postgraduate School. He has served two tours with the 116 Air Control Wing flying on the E-8C Joint Surveillance Target Attack Radar System (JSTARS) and one tour flying with the Royal Air Force version of JSTARS called the Sentinel R-1. He has over 2,100 hours as an Airborne Intelligence Officer on the JSTARS E-8C and Sentinel R-1. In his next assignment, he will serve as an airpower strategist with the NATO Air Training Command, Kabul, Afghanistan.

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ABSTRACT

For over a decade, the USAF has been looking for follow-on platforms to replace and transform the current airborne Command and Control, Intelligence, Surveillance, and Reconnaissance (C2ISR) force. The USAF has studied the feasibility of using space-based radar (SBR) platforms as well as large manned aircraft like the E-10A to meet USAF C2 and ISR operational requirements. Neither of these platforms met operational requirements and has forced the USAF to continue relying on aging AWACS and JSTARS platforms for airborne C2ISR.

The current airborne C2ISR force was designed to operate in the Cold War environment and should be replaced with newer technology to negate new information-age threats. However, does the technology exist today? Can Remotely Piloted Aircraft (RPA) or unmanned airships replace the AWACS and JSTARS? If so, what are the costs and benefits of transforming airborne C2ISR, and should the USAF transform airborne C2ISR now?

The USAF must make strategic choices today by weighing the costs and benefits of replacing or modernizing the current airborne C2ISR force. A holistic evaluation of the costs, capabilities, and cultural implications will determine whether or not the USAF should modernize or transform the current airborne C2ISR force today.

The analysis indicates that it is technologically feasible to replace the AWACS and JSTARS today with RPAs and unmanned airships. The upfront costs for making this transition will be higher, but the long-term costs will be lower. Initially, it would likely impact the culture by employing airborne C2ISR operators in ground stations instead of in the air, but in the long run, the culture may shape implementation in ways that may in turn shape the technology. The CONOPS would involve heavy reliance on satellite communications for connectivity but foster more integration between operations and intelligence by modifying the Air Force Distributed Common Ground System (AF DCGS) to support both battle management command and control (BMC2) and ISR missions. The impact on the organization and interoperability with joint and coalition forces would be positive and ensure future C2ISR capabilities are integrated in a global C2ISR infrastructure.

Finally, the USAF should transform airborne C2ISR now to reduce long-term costs while creating positive strategic effects by changing Cold War era culture, operational concepts, organization, and technology to negate 21st Century threats.

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Introduction

> *We'll continue to get rid of outdated Cold War-era systems so that we can invest in the capabilities we need for the future, including intelligence, surveillance, and reconnaissance; and the ability to operate in environments where adversaries try to deny us access.*
>
> \- President Barack Obama

United States Air Force (USAF) Intelligence, Surveillance, and Reconnaissance (ISR) transformation has been in progress for almost a decade.[1] ISR transformation focuses on improving capabilities and effects rather than personnel, platforms, and culture. Advanced technology, new operational concepts, and organizational innovation have allowed ISR to transform Cold War, industrial age capabilities to post-Cold War, information age capabilities.[2] Some of these new capabilities include Remotely Piloted Aircraft (RPA) and the Air Force Distributed Common Ground System (AF DCGS).[3] These new capabilities have enabled the Air Force to conduct persistent day, night, and all weather ISR coverage while reducing forward footprint, threats to aircrew, and life cycle costs.[4]

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[1]First phase of ISR transformation started in Feb 2006 by making XOI a Deputy Chief of Staff for ISR. "Intel deputy highlights ISR transformation progress." Air http://www.af.mil/news/story.asp?id=123069682. (Accessed 20 January, 2012)

[2] The Air Force defines transformation as fundamental change involving three principal elements and their interactions with one another: (1) advanced technologies that, because of the new capability they yield, enable (2) new concepts of operation that produce order-of-magnitude increases in our ability to achieve desired military effects, and (3) organizational changes that codifies the changes in the previous elements or enhances our ability to execute our national-security strategy. Maj Gen David A. Deptula, "USAF Transformation," *Aerospace Power Journal*, Fall 2001. 1.

[3] Lt Gen David A. Deptula and Lt Col R. Greg Brown, "A House Divided: The Indivisibility of Intelligence, Surveillance, and Reconnaissance," *Air and Space Power Journal*, Summer 2008. 2.

[4] Lt Gen (Ret) David A. Deptula, "Air Force Intelligence, Surveillance, and Reconnaissance Programs," Presentations to the House of Armed Services Committee, subcommittee on air and land forces. April 19, 2007. Retrieved from

Does the USAF's recent success in transforming ISR mean that it is feasible to transform all manned ISR systems to unmanned systems? This paper will tackle that question. The dialogue thus far has focused on up-front costs. This thesis will attempt a more holistic evaluation of the costs, capabilities, and cultural implications of making this type of transformation. This paper provides a cost-benefit analysis to determine whether or not the USAF should transform airborne C2ISR now. It will specifically address whether or not the USAF should replace the AWACS and JSTARS now with RPAs or unmanned airships.

Some senior Air Force leaders say, "ISR cannot be driven by numbers of platforms or pots of money;" however, current fiscal constraints are forcing military leaders to decide which ISR programs should stay or go.[5] For example, the U-2 Dragon Lady and the unmanned RQ-4B Global Hawk programs have fought over funding from the USAF for more than a decade, but financial pressures are forcing the USAF to terminate the RQ-4B Block 30 program while they are extending the U-2 program.[6] The USAF initially claimed the RQ-4B was cheaper and could replicate the aging U-2's ability to collect a broad range of data more safely and for longer periods of time.[7] However, recent data revealed that cancelling the RQ-4B Block 30 would save more money than cancelling the U-2 over the next 5 years.[8]

The E-8C Joint Surveillance Target Attack Radar System (JSTARS), E-3C Airborne Warning and Control System (AWACS), and RC-135 V/W

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http://www.globalsecurity.org/intell//library/congress/2007_hr/070419-deptula.pdf. 16. (Accessed 20 January 2012).

[5] Brown and Deptula, "A House Divided," 2, and SECAF ISR review memo, 28 December 2012. Both highlight ISR capabilities and future needs.

[6] Amy Butler, "USAF Weights Which ISR Program to cut," Aviation Week, 26 September 2011 http://www.aviationweek.com/aw/generic/story_channel.jsp?channel=defense&id=news/awst/2011/09/26/AW_09_26_2011_p30-373034.xml. (Accessed 20 January 2012); Department of Defense, 2012 Defense Budget and Priority Choices, January 2012, 11.

[7] Deptula, "Air Force Intelligence, Surveillance, and Reconnaissance Programs." 16.

[8]2012 Defense Budget and Priority Choices, January 2012. 11.

(Rivet Joint), also known as the "Iron Triad," are more examples of Cold War-era ISR capabilities that will likely be influenced by budget constraints. Like the U-2, these systems have exceeded their life expectancy and are forcing the Department of Defense (DOD) to determine whether or not they should be extended for another 10 to 20 years or get replaced now by RPA technology. Unlike the U-2 and RQ-4B, the JSTARS and AWACS have a Battle Management Command and Control (BMC2) mission that may be difficult for RPAs or unmanned airships to replace without applying new operational concepts and organizational innovation to the new technology. For example, JSTARS and AWACS each fly with a mission crew of approximately 18-34 Airmen and soldiers on-board the aircraft to employ ISR sensors and the communications suite for BMC2 missions.[9] In order to replace the AWACS and JSTARS with RPAs now, new operational concepts and organizational innovation (such as having a BMC2 ground station, or AF DCGS type of capability) would be needed to ensure effective BMC2. Replacing the AWACS and JSTARS now with RPAs will change the airborne C2ISR concepts of operation (CONOPS), but will it save money and improve future C2ISR capabilities?

In addition to costs, the USAF must look at whether current and new C2ISR systems are capable of dominating in an environment that has yet to evolve and countering adversaries who have yet to materialize. For example, information age conflicts against the U.S. will likely involve "anti-access and area-denial (A2AD)" weapons. The 2012 Defense Strategic Guidance states, "The U.S. military will invest as required to ensure its ability to operate in A2AD environments."[10] Will current or new C2ISR systems have the capability to operate in such environments?

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[9] Major Stephen C. Price, Jr. "Close ISR Support: Re-organizing the Combined Forces Air Component Commander's Intelligence, Surveillance, and Reconnaissance Processes and Agencies." Master's thesis, Naval Postgraduate School, December 2009, 307.
[10] See Department of Defense, Sustaining U.S. Global Leadership: Priorities for 21st Century Defense, January 2012. http://www.defense.gov/news/Defense_Strategic_

The questions and issues raised above have been debated for more than a decade. The USAF has conducted a few studies and experiments on transforming airborne C2ISR. Some of the airborne C2ISR transformation studies, for example, looked at replacing airborne platforms with space-based platforms and combining the AWACS and JSTARS capabilities on a single Multi-sensor Command and Control Aircraft (MC2A) or E-10A platform.

Background

In the late 1990’s and early 2000’s, the USAF studied the feasibility of using space-based Moving Target Indicator (MTI) platforms to replace the JSTARS and AWACS. This study found that space-based platforms could not provide adequate MTI coverage due to physical laws of space and sensor limitations. For example, for air and ground surveillance, satellites equipped with radar need to loiter over a geographical area of interest to provide continuous coverage. However, the only satellites that can loiter need to operate at considerable altitudes are too high to permit adequate radar resolution for MTI purposes. Additionally, even with improved radar resolution, space-based MTI studies estimated that 12 to 70 satellites would be required to prevent gaps in coverage.[11] While research and development of space-based MTI was being conducted, the USAF was continuing its quest to transform airborne C2ISR using newer airborne platforms to replace the JSTARS and AWACS.

In the early 2000’s, the USAF initially identified the E-10A as a transformational airborne C2ISR capability. The E-10A fused the Multi-Platform Radar Technology Insertion Program (MP-RTIP) and BMC2 mission suite into a modified Boeing 767-400 Extended Range platform. Additionally, the E-10A combined the AWACS and JSTARS capabilities

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Guidance.pdf. (Accessed 23 January 2012)

[11]Major Kim Corcoran, “Higher Eyes in the Sky: The Feasibility of Moving AWACS and JSTARS Functions into Space.” School of Advanced Air and Space Studies, Air University, June 1998. 92.

into a single platform. Initial software and sensor integration problems caused delays in this program, and many analysts claimed that the E-10A was not transformational and reflected operational concepts, organization, and technologies present in existing Cold War-era airborne C2ISR platforms.[12] The USAF eventually terminated the E-10A program in 2010 due to budget cuts and the E-10A's inability to provide significant improvements to warfighting capabilities that would justify its $20 billion cost.[13]

Significance of the Problem

While the USAF looks for follow-on airborne C2ISR capabilities it continues to rely on the Iron Triad fleet for airborne C2ISR. These aging platforms are considered Low Density/High Demand (LD/HD) assets and are based on a 50+year-old Boeing 707 airframe that continuously operates at surge capacity. Additionally, the current airborne C2ISR force was designed to operate in the Cold War environment and should be replaced with newer technology to negate new information age threats. The question then becomes, what capabilities can replace the Iron Triad? Can RPAs or unmanned airships improve the AWACS and JSTARS capabilities while reducing life cycle costs? If so, should the USAF replace the JSTARS and AWACS with RPAs now?

Methods and Thesis Overview

This paper provides a cost-benefit analysis to determine whether or not the USAF should transform airborne C2ISR now. More specifically, this paper provides a holistic assessment by comparing various airborne C2ISR capabilities and costs while analyzing how certain systems will impact the USAF's C2ISR culture, organization, and interoperability with

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[12] Major Yvette S. Quitno, "Transformational Command and Control, Intelligence, Surveillance, and Reconnaissance (C2ISR): The E-10 and Implications for the Future," School of Advanced Air and Space Studies, Air University, June 2004. 8.

[13] Defense Industry Daily. "E-10A: She's dead Jim," http://www.defenseindustrydaily.com/e10a-shes-dead-jim- 03139/. (Accessed 20 January 2012).

coalition partners. First, the study examines the USAF's operational requirements for airborne C2ISR and provides a capability analysis on the AWACS, JSTARS, RPAs, and unmanned airships to determine which systems can best meet these requirements in the future. It then provides a financial analysis to determine which systems are the most cost effective now and in the long term. Lastly, this paper analyzes how RPAs and unmanned airships would require a change in the USAF's C2ISR culture and organization by transforming airborne C2ISR operational concepts. It will also investigate how this transformation will impact C2ISR interoperability with our allies.

The study relies heavily on official interviews, briefings, publications, articles, and journals from DOD members from various organizations such as Office of the Secretary of Defense (OSD), Defense Advanced Research Program Agency (DARPA), Headquarters Air Force (HAF), Air Combat Command (ACC), and the Air Force Research Laboratory (AFRL). Primary sources were used whenever possible, but secondary sources also helped fill gaps in the strategic picture.

Scope and Limitations

The author acknowledges certain limitations to the study. First, this paper relies only on unclassified information and sources to provide an assessment of current capabilities and technology to determine the feasibility of transforming airborne C2ISR. Many of the vulnerabilities and limitations to airborne C2ISR systems are classified and not considered in this study. Additionally, many requirements documents were unavailable due to classification issues. Comprehensive analysis of classified requirements documents such as the Defense Planning Guidance (DPG) and the JSTARS Analysis of Alternatives (AOA) was not accomplished. Additionally, this study does not include an analysis of replacing the RC-135 V/W (Rivet Joint) with RPAs and unmanned airships due to issues concerning classification; however, similar

methods at the classified level can be applied to determine the feasibility of replacing the Rivet Joint with RPAs or unmanned airships.

This study centers on USAF airborne C2ISR assets. C2ISR spans many media including air, space, maritime, and ground. But the scope of this investigation encompasses only airborne C2ISR assets to analyze the feasibility of transforming airborne C2ISR today. Additionally, this is a single service perspective expressed in the focus on USAF airborne C2ISR. The reason for this limitation is that the USAF owns the majority of airborne C2ISR platforms, and the resource budgets are also service-centric. Finally, the Army does not have current or future GMTI/SAR requirements that would impact the acquisition of a follow-on JSTARS capability.[14] The Army has also decided to remove Army personnel from the E-8C and JSTARS Air Force Wing at Robins Air Force Base by October 2013.[15] This may be an indication that the Army is looking to save costs and move away from the old Cold War GMTI/SAR collection construct.

Organization of paper

Chapter 1 provides a capability assessment by analyzing and comparing the JSTARS and AWACS, with the RQ-4B Block 40, MQ-9 (VADER and DDR) RPAs and the Integrated Sensor is Structure (ISIS) unmanned airship. First, this chapter determines the operational requirements for airborne C2ISR using the USAF Core Functional Master Plan (CFPM) and the U.S. Strategic Command's (USSTRATCOM) desired MTI and SAR attributes and capabilities as a framework for comparing airborne C2ISR capabilities. Second, it provides a brief overview of the AWACS and JSTARS capabilities and modernization plans for the next 20 years. Third, it analyzes RPAs and unmanned airship technology to see if it is feasible for these new capabilities to replace the AWACS and

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[14] Bryan Wutkis, U.S. Army Training and Doctrine Command (TRADOC) staff at Ft Huachucca in discussion with the author on 15 February 2012.
[15] Ibid.

JSTARS today. Additionally, it explores the idea of creating an integrated C2 and ISR ground station by modifying an AF DCGS to facilitate an effective transition. Finally, chapter 1 discusses some basic concepts of operations (CONOPS) to support these ideas and shows how many RPAs and unmanned airships would be required to replace the AWACS and JSTARS fleet and what capabilities would be lost or gained.

Chapter 2 examines the life cycle costs of the AWACS and JSTARS compared with the life cycle costs of RPAs and unmanned airships. It specifically looks at sustainment and modernization costs to determine which systems would be most cost-effective over the next 10-20 years.

Chapter 3 analyzes the cultural implications of transforming airborne C2ISR. It also assesses likely changes in organizations and other areas of airborne C2ISR CONOPS not covered in chapter 1. Finally, it explains how the USAF would remain interoperable with the North Atlantic Treaty Organization (NATO) and United Kingdom (UK) C2ISR community. The concluding chapter summarizes these findings along with the findings in chapters 1 and 2 and provides an overall assessment aimed at determining whether or not the USAF should transform airborne C2ISR now.

Chapter 1

Airborne C2ISR Capability Analysis

We are making deliberate strategic choices about key programs and capabilities that need to go forward so that we still have the finest military in the world 10 years from now.

- Secretary of the Air Force Michael B. Donley

The USAF is known for embracing technology to improve military capabilities. Recently, the USAF ISR community embraced RPA technology that transformed the Find, Fix, Track, Target, Engage, and Assess (F2T2EA) kill chain.[1] The transformation of the F2T2EA kill chain was possible because RPA technology was integrated in a global ISR infrastructure. The USAF developed the global ISR infrastructure to not only fly but also analyze the data from these systems anywhere on earth while making it available in C2 nodes. This provides the ability to see and strike targets even in politically sensitive environments where the weapons release authority is at a very high level. Additionally, the use of RPA technology changed the USAF's approach to conducting ISR. The innovative lessons learned from early RPAs, such as the MQ-1, have enabled the USAF to conduct multiple core function missions, such as

[1] Col Veralinn "Dash" Jamieson, former Director of ISR Transformation, HQ USAF, " Application of ISR Capabilities to Tighten the Kill Chain, USAF Perspective," unclassified briefing retrieved from http://www.dtic.mil/ndia/2008psa_winter/ jamieson.pdf. (Accessed 12 March 2012). F2T2EA kill chain is a dynamic targeting process consisting of six phases: find, fix, track, target, engage, and assess. These six steps are commonly referred to as "F2T2EA" or the "kill chain" and are used in multiple cases to analyze and control tactical operations. The kill chain process can be applied against planned targets, JFC-approved TSTs, targets considered crucial for blue force success, emerging targets and scheduled targets whose status has changed to a higher priority. Air Force Doctrine Document 2-1.9 (AFDD 2-1.9), 8 June 2006.

ISR and strike, simultaneously from a single platform.[2] This type of innovation and increased use of current technology will likely transform airborne C2ISR missions in the future. How gradual should this transformation be? Can the AF intentionally transform airborne C2ISR now? This chapter will examine the ability of RPAs and unmanned airships to replace the AWACS and JSTARS now. It determines that RPAs and unmanned airships can replace the AWACS and JSTARS capabilities today, but it is not a simple one-to-one replacement and necessitates a more in-depth cost analysis later. The first section will examine the USAF's operational requirements for airborne C2ISR and moving target indicator (MTI)/synthetic aperture radar (SAR).[3] It will then compare the capabilities between the AWACS and JSTARS and the RQ-4B Block 40 and MQ-9 (VADER and DDR) RPAs and the Integrated Sensor is Structure (ISIS) unmanned airship. Finally, it analyzes the overall capabilities by showing what will be lost or gained and whether or not current RPA and unmanned airship technology can support the USAF's operational requirements essential to transforming airborne C2ISR today.

Operational Requirements for Airborne C2ISR

> *The Air Force's 12 Service Core Functions…form a reference point for helping the service mold its strategic priorities, risks, and tradeoffs.*
>
> - Secretary of the Air ForceMichael B. Donley

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[2] Lt Col Michael W. Kometer, *Command in the Air: Centralized versus Decentralized Control of Combat Airpower*, (Air University Press 2007), 214-215. Ideas were taken from this book and expanded to include how armed RPA's have reduced the kill chain by enabling armed ISR platforms to find, fix and engage targets.

[3] Moving target indicator (MTI) is generated from pulse-doppler radars that distinguish clutter from moving objects in the air or on the ground. There are two types of MTI: Airborne MTI (AMTI) and Ground MTI (GMTI). Synthetic aperture radar (SAR) is a coherent radar, commonly used with GMTI, that generates high-resolution remote sensing non-literal imagery that can be photo-like in appearance and resolution. Richard Dunn, Price Bingham, Charles Fowler, "Ground Moving Target Indicator Radar and the Transformation of U.S. Warfighting," (Northrop Grumman Analysis Center Papers, February 2004). 7.

Before comparing RPAs and the ISIS unmanned airship with the AWACS and JSTARS capabilities, it is important to understand the USAF's operational requirements for airborne C2ISR. Such requirements provide a framework for comparing the various airborne C2ISR platforms. Currently, no document provides specific requirements for all airborne C2ISR platforms. Therefore, this paper will use the Air Force CFMP and USSTRATCOM's desired MTI and SAR attributes and capabilities to build a framework to determine operational requirements for airborne C2ISR. The USAF separates BMC2 from ISR making them two core functional areas that are highlighted in the CFMP. The USSTRATCOM's desired MTI and SAR capabilities and attributes include inputs from all Combatant Commanders (COCOM). This analysis deconstructs each platform into three parts: the aircraft, the sensor for ISR, and the communications suite for BMC2. Each part will be analyzed against the operational requirements for BMC2 and ISR. This section will look at the C2 and Global Integrated (GI) ISR CFMP and STRATCOM's desired MTI and SAR capabilities and attributes to determine operational requirements for airborne C2ISR.[4]

Command and Control Core Functional Master Plan (C2 CFMP)

The C2 CFMP provides broad guidance on the USAF's C2 operational requirements and helps the USAF to mold its strategic priorities, risks, and tradeoffs.[5] According to the Joint C2 Functional Concept, "Command and control is the ability to recognize what needs to be done in a situation and to ensure that effective actions are taken. At its core, C2 is about decision making and the individual who makes decisions."[6] BMC2 is a subset of Joint C2 and is the ability to exercise

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[4] Global Integrated Intelligence, Surveillance, and Reconnaissance and Command and Control Core Functional Master Plan (GI ISR and C2 CFMP) document provided by ACC/A2C/A3C, 16 January 2012.

[5] Ibid.

[6] Joint C2 functional Concept document provided by ACC/3C via e-mail on 16 January 2012.

appropriate and effective C2 of assigned assets at the tactical level. The AWACS and JSTARS BMC2 role puts a C2 function within line-of-sight of the tactical aircrews, providing these crews the benefit of their improved information due to their sensors and on-board information systems. This allows them to provide situational awareness to the aircrews to make decisions rapidly. The AWACS and JSTARS BMC2 role supports over a dozen different airpower missions, providing situational awareness and timely tactical employment decisions to coalition forces performing these missions.[7]

There are two important features that enable effective BMC2: computers and communications equipment. The C2 CFMP identifies the operational requirements as the capability to conduct BMC2 globally and in-theater by using available platforms and networks to communicate at all levels of war.[8] It also states, "Airborne platforms must have the capability to relay information in both friendly and hostile environments, around-the-clock while limiting its dependence on satellite connectivity."[9] Some military analysts say that having tactical aircrew flying over the battlefield can reduce communications risk by providing secure line-of-sight (LOS) communications with air and ground strike assets, decreasing dependence on satellite connectivity for communications. Other analysts say that the aircraft avionics and sensor equipment also rely on satellite connectivity for critical data and any loss of satellite connectivity would result in overall degradation of the mission; therefore,

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[7] BMC2 supports airpower missions such as Offensive Counter Air (OCA), Defensive Counter Air (DCA), Suppression and Destruction of Enemy Air Defense (SEAD and DEAD), Strike Coordination and Reconnaissance (SCAR), Air Interdiction (AI), Close Air Support (CAS), High-Valued Air Assets (HVAA), Intelligence, Surveillance and Reconnaissance (ISR), Electronic Warfare (EW), Aerial Refueling (AR), Combat Search and Rescue (CSAR), and Special Operations, Air Combat Command Joint Surveillance Target Attack Radar (JSTARS) Enabling Concept, 1 September 2009, provided to author by ACC/A3C via e-mail 6 January 2012.

[8] Command and Control Core Functional Master Plan (C2 CFMP) document provided by ACC/A2C/3C via e-mail, 6 January 2012.

[9] Ibid.

it would make no difference if the aircrew operated within LOS or beyond line-of-sight (BLOS).[10] On the other hand, the C2 CFMP states that BMC2 platforms must have redundant capabilities to negate new threats to information and decrease vulnerabilities."[11] Therefore, one could argue that aircrew flying over the battlefield could provide more redundant communications through various BLOS and LOS voice and data links. The requirements are broad in nature and do not specify the type of aircraft or equipment required to provide this capability. However, current intelligence assessments reveal that adversaries are developing technology to degrade and deny USAF airborne C2ISR sensors and communications.[12] The operational requirements stated in the CFMP support the 2012 Defense Strategic Guidance: "The U.S. military will invest as required to ensure its ability to operate in anti-access and area denial (A2AD) environments."[13] Therefore, BMC2 capabilities must be able to operate in A2AD environments in the future.

To allow for an effective BMC2 mission transition from manned to unmanned airborne C2ISR systems, people would have to perform this function somewhere other than the aircraft. The logical place would be another C2 node, such as the Command and Reporting Center (CRC).[14] Alternatively, the BMC2 mission could co-exist with the ISR mission in

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[10] ACC/A3C staff in discussion with author, 16 January 2012.
[11] Ibid.
[12] Lt Gen Ronald L. Burgess, Defense Intelligence Agency's (DIA) World Wide Assessment: 2020, 10 March 2011, 29.
[13] See Department of Defense, Sustaining U.S. Global Leadership: Priorities for 21st Century Defense, January 2012. http://www.defense.gov/news/Defense_Strategic_Guidance.pdf. (Accessed 23 January 2012).
[14] The CRC is a ground-based surveillance and battle management command and control (BMC2) element. It consists of facilities, equipment, and people. It is a modular, transportable, sustainable, and persistent weapon system employed at the tactical level to support air and surface operations. The TPS-75 air surveillance radar is usually located at each CRC site. ACC/A3C, Air Combat Command, Command and Control Reporting (CRC) Enabling concept, 1 November 2008 e-mailed to author on16 Feb 2012.

an AN/GSQ-272 AF DCGS.[15] These ground stations would require a gateway and would have to provide secure voice and data communications via LOS and BLOS to numerous air and ground assets. RPAs such as the EQ-4B Battlefield Airborne Communications Node (BACN) can provide this gateway and also meet C2 operational requirements by providing redundant communications capabilities.[16] U.S. and coalition air and ground assets must train with this new operational concept to ensure any BMC2 gaps are filled. In a coalition type of battlefield seen in Operation Enduring Freedom (OEF) in Afghanistan today, the AWACS and JSTARS platforms have been force enablers which bridged the BMC2 gap with coalition air and ground assets. Various nations rely on different types of communications equipment, and removing this capability from today's battlefield could be life threatening to coalition forces.[17] On the other hand, as coalition forces move towards network-centric warfare capabilities in the next 10 to 20 years, certain communications equipment may no longer be required. Finally, the USAF's BMC2 employment methods must be interoperable and compatible with multiple aircraft to allow for distribution or communications sharing with other U.S. and coalition aircraft or ground forces.[18] Some of the key attributes for BMC2 missions are similar to the attributes required for ISR missions. These

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[15] The AN/GSQ-272 Air Force Distributed Common Ground System (AF DCGS) is a network-centric weapon system capable of tasking ISR sensors and receiving, processing, exploiting, correlating, and disseminating data/info/intelligence from airborne, national, and commercial platforms and sensors. It is a "virtual backend crew" for the U-2, Global Hawk, Predator, Reaper and MC-12W in support of joint warfighters. AF DCGS Overview briefing by Capt Sean Piccirilli, HQ USAF/A2RM, February 2012.

[16] EQ-4 Battlefield Airborne Communications Node (BACN) is an airborne communications relay and gateway system that provides radio connectivity across the battlefield for air and ground operators. BACN enables real-time information flow between similar and dissimilar tactical data and voice systems through relay, bridging, and data translation in line-of-sight and beyond line-of-sight situations. Unclassified HAF/A2C Global Hawk briefing by Lt Col Rick Thomas on 11 March 2012.

[17] ACC/A3C staff in discussion with the author on 16 February 2012.

[18] C2 CFMP document provided by ACC/A3 via e-mail on 16 January 2012.

attributes include sensor payload flexibility with capabilities for specialized communication radios and antennas.

Global Integrated ISR Core Functional Master Plan (GI ISR CFMP)

Similar to the C2 CFMP, the GI ISR CFMP provides guidance on ISR operational requirements and helps the USAF to mold its strategic priorities, risks, and tradeoffs.[19] The airborne ISR operational requirements include the ability to detect, track, and report enemy activity in all weather, day or night. Additionally, the GI ISR CFMP states that, "airborne ISR platforms must have sufficient speed, altitude, and maneuverability to enable survivability in contested environments."[20] In order to maintain situational awareness, the CFMP requires ISR platforms to be able to support multiple objectives or engagements and therefore requires significant mission range and persistence. To this end, it also maintains that flexibility in communications, weapons, and sensors are critical.

New sensor technology such as the active electronically scanned array (AESA) is critical in allowing the USAF to dominate in future A2AD environments. The AESA radar is technologically superior to the older electronically scanned array (ESA) sensors on the AWACS and the JSTARS. It uses hundreds or even thousands of stationary sensor elements to act as transmitter/receivers to provide continuous, real-time target position up to six times faster than the AWACS and JSTARS radars. The AESA radar has very agile beams that can be positioned anywhere in less than a millisecond—compared to seconds for mechanical antennas—and the agility of the beams allows tracking as soon as a target is detected. The AESA radar also provides lower minimum detectable velocity, smaller radar cross-section (RCS) detection, better resolution/geospatial accuracy, and track persistence

[19] Ibid.
[20] GI ISR CFMP document provided by ACC/A2 on 16 January 2012.

over entire radar coverage.[21] Additionally, the AESA radar's ability to steer beams independently improves the radar's capability against electronic attack (EA) while allowing it to continuously track three times the number of targets that the AWACS and JSTARS radars can.[22] This capability is significant when going up against newer and faster aircraft as it will provide faster updates highlighted in the DOD's strategic guidance and the CFMP.[23] Finally, like the BMC2 operational requirements, the USAF's airborne ISR capabilities must be compatible with multiple aircraft to allow for distribution of data or sharing of sensor data with other U.S. and coalition aircraft or ground forces.[24]

USSTRATCOM's desired MTI and SAR Capabilities and Attributes

In May 2010, the USSTRATCOM (along with all Combatant Commanders) identified a series of MTI and SAR sensor and system characteristics that included six priorities: 1) area (Army corps size area 300 km x 300 km; 2) persistence (24 hours a day, 7 days a week); 3) timeliness; 4) dynamic re-tasking; 5) accuracy; and 6) data distribution.[25] These USSTRATCOM priorities and the USAF CFMP will

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[21] Tim Clark, Project Manager for ISIS, Unclassified DARPA AESA Radar briefing, November 2007 provided to author via e-mail on 16 March 2012.

[22] Ibid.

[23] Defense Strategic Guidance, Global Leadership: Priorities for 21st Century Defense, January 2012, www.defense.gov/news/Defense_Strategic_Guidance.pdf. 4. (Accessed 17 January 2012) and C2ISR CFMP.

[24] ACC/A2C, GI ISR CFMP document provided to author via e-mail on 16 January 2012.

[25] The six MTI and SAR platform priorities stated in USSTRATCOM's desired MTI and SAR capabilities and attributes are: (1) it must have sufficient area coverage (Army Corps size area of 300km x 300km) capability to successfully locate and track the full spectrum of airborne and surface-based targets anywhere, anytime, and in any weather day or night; (2) it must be able to provide persistent coverage by providing sufficient time on station to accomplish the assigned mission against the designated target or over the specified area of interest, day or night, 24 hours a day and 7 days a week with 80% reliability; (3) it must have the capability to accurately determine target location in a timely manner to support warfighter engagement and intelligence analysis; (4) it must be able to alter and/or scale collection activities to respond to dynamic re-tasking and emergent changes in focus, priority, threat, or capability; 5) the target location accuracy (TLA) for wide area surveillance platforms must be less than 20 meters and have a revisit rate less than 30 seconds; and 6) it must be able to disseminate data to multiple joint and coalition sensor/weapon systems via Common Data Link Military Standard (CDL-MILSTD) and NATO Standardization Agreement (STANAG), and provide

be used to assess whether or not newer C2ISR systems can meet operational requirements. The E-3C and E-8C are examples of the USAF's airborne C2ISR capabilities that currently meet these BMC2 and ISR operational requirements today.

E-3C AWACS and E-8C JSTARS Capabilities Analysis

For over two decades, the AWACS and JSTARS have been the USAF's primary airborne C2ISR platforms. These platforms are based on a 50+ year-old Boeing 707-300 series airframe and were designed to operate in the Cold War environment. Modernization and recapitalization efforts are projected to keep these platforms in service past their original service lives. For example, the AWACS was originally projected to retire by 2025. However, future aircraft and mission system upgrades could allow the AWACS to remain flying until 2035.[26] The JSTARS was projected to retire by 2020, but the Air Force is currently looking at options such as engine upgrades and mission system modernization to extend the platform life for another 10 to 20 years.[27] The next section will examine current capabilities of the AWACS and JSTARS in three separate distinct areas: the aircraft, the sensor for ISR, and the communications suite for BMC2. Additionally, it will assess mobility requirements such as personnel manning, equipment, and logistical footprint associated with each manned and unmanned system.

E-3C AWACS

Aircraft

The E-3C AWACS aircraft is aging; however, the large number of aircraft allows for flexibility and the simultaneous conduct of training

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seamless information sharing to support fused multi-source analysis for persistent situational awareness. United States Strategic Command's desired MTI and SAR Capabilities and Attributes, May 2010 e-mailed to the author on 16 February 2012.

[26]ACC/A3C, Air Combat Command, Airborne Warning and Control System (AWACS) enabling concept, 1 December 2008 provided to author via e-mail, 16 February, 2012.

[27] Lt Col Charlie Brown, ACC/A8Y, discussion with author, 9 February 2012.

and real-world operations.[28] The AWACS is a modified Boeing 707-300 series aircraft with TF-33 Pratt and Whitney-100A turbo fan engines. These engines allow the E-3C to operate at Flight Level (FL) 290 to FL 350.[29] It is capable of flying up to 9 hours unrefueled and up to 21 hours with aerial refueling and with an augmented crew. The 9 hour unrefueled duration allows the aircraft to fly to and from the area of operation to maintain a typical duration of 6 hours on station. The E-3C's aerial refueling capability allows the aircraft the flexibility to remain on station longer if the replacement aircraft is unable to arrive on time due to weather or maintenance issues. The USAF has 33 E-3s today; one of the aircraft is a test bed for upgrades and modifications, and five are usually in maintenance depot. That leaves 27 available for training and worldwide deployments.[30] The large number of E-3C aircraft is a significant strength because it allows the USAF to provide Airborne Early Warning in multiple combat theaters, as well as homeland defense, while simultaneously continuing basic and advanced training at home station. Each E-3C in the entire fleet has the same ISR sensor (the radar) and an identical communications suite for BMC2.

Sensor for ISR

The AWACS sensor is also aging and considered older technology.[31] It relies on the AN/APY-1/2 radar for Airborne Moving Target Indicator (AMTI) and has an Identification of Friend or Foe/Selected Identification Feature (IFF/SIF) interrogator installed in a rotating radome, commonly

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[28] ACC/A3C staff in discussion with the author on 16 February 2012.

[29] A flight level (FL) is a standard nominal altitude of an aircraft in feet, divided by 100. For example, 29,000 feet is referred to as "flight level 290." United States Department of Transportation Federal Aviation Administration, Airplane Flying Handbook, http://www.faa.gov/library/manuals/aircraft/airplane_handbook/media/faa-h-8083-3a-1of7.pdf. (Accessed 24 May 2012).

[30] U.S. Air Force fact sheet, www.af.mil/information/factsheets/factsheet.asp?fsID=98 (accessed on 9 February 2012).

[31] Colin Clark, "Scrap AWACS, JSTARS; Plough dough into F-35, Wynne says," DOD BUZZ Online Defense and Acquisition Journal, 31 January 2011. Retrieved from http://www.dodbuzz.com/2011/01/31/scrap-awacs-jstars-plough-dough-into-f-35/ on 16 March 2012.

referred to by the AWACS community as the “rotodome,” above the fuselage for detection, tracking, and identification of friendly or hostile aircraft.[32] Its rotational radar antenna provides relatively slower updates in comparison to newer radar because each target will only be painted when the radar passes through that target’s azimuth. In contrast, newer phased-array radars such as AESA provide faster and continuous updates that are critical when going up against newer and faster aircraft as mentioned earlier.

A positive aspect of the AWACS sensor is that it can scan 360 degrees while detecting and tracking airborne moving objects beyond 375 km. It can also monitor 125,000 square miles with every sweep of its beam.[33] The greater the range at which a sensor can detect and track airborne “movers” inside enemy territory, the more time aircrews and commanders have to decide if, when, and where to engage. The airborne stand-off range also keeps the E-3C crew outside the range of most surface-to-air missile systems and airborne intercept fighters. Unfortunately, a negative aspect of the E-3C’s older radar technology is that it is unable to detect very low radar-cross-section targets such as stealth aircraft or cruise missiles.[34] This lack of capability will be vital in an air conflict against a country that possesses fifth-generation stealth fighters.

In addition to the AN/APY-1/2 radar and IFF/SIF interrogator, the AWACS has an electronic support measures (ESM) system to support combat identification (CID) of air and surface emitters. This capability allows the AWACS to not only electronically identify targets detected by its radar, but also correlate them with targets detected by other

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32 Ibid.
33 ACC/A3C unclassified E-3C capabilities briefing received on 15 February, 2012.
34 David A. Fulghum, "Intel, Anti-Stealth Part of Tanker Spinoff." *Aviation Week & Space Technology,* Vol. 156 Issue 9 (4 March 2002): 43-44.

platforms such as the JSTARS that lack the ESM capability.[35] The ESM provides additional situational awareness and intelligence critical to effective BMC2.[36] Using the BMC2 capability, the AWACS has the ability to disseminate sensor data to multiple airborne and ground coalition assets simultaneously to assist in engaging of hostile targets and avoid fratricide.[37]

Communications suite for BMC2

The AWACS communications suite provides a redundant communications capability in accordance with the C2 CFMP. It is equipped with over a dozen UHF radios, two HF radios, four VHF radios, and two satellite communications (SATCOM) radios for secure voice and data. Additionally, AWACS is equipped with Joint Tactical Information Distribution System (JTIDS) or Link-16 that is used for secure voice and data communications with other airborne and ground assets.[38] It also uses one of the SATCOM radios for Secret Internet Protocol Network (SIPRNET) chat to communicate real-time at the tactical and operational levels of war.[39] The large number of voice and data communications allows the AWACS crew members to communicate with many different joint and coalition forces including C2 nodes all the way from the tactical to the strategic level. The AWACS flies with 18-34 aircrew and is divided into four functional areas: flight crew, technicians for radar and communications, surveillance personnel, and weapons controllers. The AWACS aircrew uses the LOS and BLOS communications to coordinate operational and tactical-level tasking to coalition forces in the air and on the ground. That means the AWACS aircrew can simultaneously coordinate with the combined air operations center (CAOC) at the

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[35] Ibid.

[36] David L. Adamy, *Introduction to Electronic Warfare*, (Artech House, 2003). 35.

[37] ACC/A3C unclassified E-3C capabilities briefing received via e-mail on 15 February, 2012.

[38] Ibid.

[39] Ibid.

operational level and with other air or ground assets on the battlefield at the tactical level. This capability fulfills the C2 CFMP operational requirements to have redundant capabilities to reduce its vulnerability. For example, if the AWACS lost SATCOM capability critical to SIPRNET chat and could not transmit or receive Link-16 tracks to other airborne or ground assets, it could easily transmit and receive the information via LOS and BLOS UHF, VHF, or HF radios. Additionally, the AWACS aircrew can utilize LOS radios to generate, receive, access, correlate, fuse, combine, and disseminate sensor and TDL (Tactical Data Link) data to provide a comprehensive and accurate air and surface tactical picture to Air Tasking Order (ATO) participants, authorized users, and higher headquarters (HHQ).[40] In order to maintain current voice and data communications over the next 20 years, the AWACS will require various upgrades and modifications to allow it to participate in a network-centric environment.

AWACS modernization to 2035

The AWACS modernization is an important factor in complying with operational requirements and extending its service life. The USAF has approved the AWACS modernization process in the near and midterm in the Program Objective Memorandum (POM) process. The modernization process will improve the AWACS sensor and software integration essential to maintaining interoperability with coalition and joint assets. These upgrades include battle management tools, computing and displays, combat identification, and data link. These upgrades will improve network-centric operations using Commercial Off-The-Shelf (COTS) hardware and software to increase combat identification through fusion with off-board sensors. The first 6 aircraft are expected to be modified by 2014 and the remaining 26 aircraft by 2020. The block 40/45 upgrade is expected to extend the AWACS service life out to 2035.

[40] Ibid.

The total cost for this initiative is $2.9 billion.[41] However, these modifications do not include any upgrades to the radar critical to ensuring the AWACS can detect emerging low radar-cross-section (RCS) targets such as stealth aircraft or cruise missiles.[42] The lack of improved radar capability brings into question the AWACS capability to operate in an A2AD environment. As we will see, the E-8C faces similar modernization challenges.

E-8C JSTARS

Aircraft

Like the E-3C AWACS, the E-8C JSTARS is also aging; however, the large number of aircraft allows for flexibility, simultaneous training, and real-world operations. The JSTARS is a modified Boeing 707-300 series aircraft with TF-33-Pratt and Whitney-100A turbo fan engines; however, the JSTARS aircraft was built on refurbished Boeing 707 airframes, which have driven up maintenance costs more quickly than if newer airframes had been chosen. The current JSTARS TF-33 engine limits its operating altitude from FL 290 to FL 350. The lack of ability to fly higher than FL 350 limits the sensor's range and ability to detect ground movement in certain types of terrain.[43] Like the AWACS, the JSTARS is capable of flying 9 hours unrefueled and 21 hours with aerial refueling and with an augmented crew. This allows the JSTARS aircraft flexibility to stay longer on station if its replacement aircraft is delayed due to weather or maintenance issues. The USAF has 17 E-8Cs today. One of the aircraft is a test bed for upgrades and modifications, and three are usually in maintenance depot. That leaves 13 available for training and worldwide deployments.[44] The fewer number of the JSTARS aircraft

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[41] Brandice J. Armstrong, "General Bowlds, others discuss AWACS modernization project," 72nd Air Base Wing Public Affairs. (Accessed 20 January, 2012)

[42] ACC/A8Y staff discussion with author on 6 February 2012.

[43] Ibid.

[44] U.S. Air Force fact sheet, www.af.mil/information/factsheets/factsheets.asp? =100 (accessed on 9 February 2012).

compared to the AWACS makes it challenging to support more than one major combat operation and theater at a time as well as basic and continuation air and ground crew training.

Sensor for ISR

The size of the JSTARS sensor allows for significant wide-area coverage; however, it is limited by the aircraft's inability to climb higher than FL 350. The JSTARS AN/APY-7 radar is 24 feet long and mounted under the fuselage. The sensor uses ground moving target indicator (GMTI) and synthetic aperture radar (SAR) to detect and track stationary and moving vehicles or aircraft taxiing prior to take off. The JSTARS radar can cover a 300 km x 300 km area of terrain (or Army Corps size area) at an airborne stand-off range of approximately 100 km from the target area.[45] At this range, the sensor can provide target location accuracy less than the 20 meters in accordance with the USAF's operational requirements. This is a significant advantage for coalition forces as one JSTARS aircraft can support many units on the ground simultaneously. However, the aircraft's inability to climb higher than FL 350 creates terrain-masking issues when operating in mountainous terrain and limits its LOS range.

Airborne ground surveillance radars face a demanding mission and benefit from flying at higher altitudes. While air-scanning radars such as the AWACS monitor a comparatively clutter-free domain, ground surveillance radars encounter obstructions in urban areas and hilly terrain which often block the radar signal. Just as in the air-to-air arena, the ground target's size and distance from the radar, plus its speed, dictates the range at which an airborne ground surveillance radar can detect and track it. Smaller targets may require focused radar energy to detect and track ground movement.

Like the AWACS, the JSTARS radar is considered older technology

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[45] Ibid.

when compared with newer AESA sensors. For example, the JSTARS radar is unable to collect and process GMTI and SAR simultaneously.[46] This limitation can be critical if the crew is trying to provide air and ground assets with timely track updates while imaging ground targets requested in the CAOC ISR collection deck.[47] The SAR image quality is also not as good as SAR imagery from the AESA radar. Furthermore, because it doesn't have sophisticated processing techniques, the current radar would not be very good at detecting lower RCS targets such as cruise missiles or stealth vehicles. The inability to detect stealthy ground or low, slow-flying targets may be vital when operating in an A2AD environment as situational awareness of friendly forces would be degraded.[48]

The exploitation and correlation of GMTI and SAR is conducted near-real time (NRT) in the air by E-8C aircrew or on the ground by the Army Common Ground Station (CGS) crew and the JSTARS GMTI cell located at Robins Air Force Base.[49] The AF DCGS does not currently conduct NRT exploitation or correlation due to lack of manning and other ISR sensor exploitation priorities.[50] The JSTARS ground nodes can conduct NRT GMTI and SAR exploitation because of the redundant communications suite.

Communications suite for BMC2

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[46] Sandra Erwin, "Air Force to Run Wars From Sensor-Packed Jets," National Defense, Vol. 88, Issue 596 (July 2003): 18.

[47] The Combined Forces Commanders (CFC) delegates the Combined Air Operations Center (CAOC), Intelligence, Surveillance, and Reconnaissance Division (ISRD) to task coalition ISR assets daily using the CAOC Air Tasking Order (ATO) Reconnaissance and Surveillance Tasking Annex (RSTA) and ISR collection deck based on the CFC ISR collection priorities. The ISR collection deck indicates the specific collection parameters needed for each target. (i.e. target location, size of collection area, duration and frequency, and methods of dissemination)

[48] Based on the author's personal experience.

[49] Based on the author's personal experience. The GMTI cell at Robins AFB can provide limited GMTI exploitation and correlation support upon request. The JSTARS sensor data is received by SATCOM data and the SIPRNET.

[50] Capt Sean Piccirilli, HAF/A2RM, AF DCGS capabilities briefing provided via e-mail to author on 16 March 2012.

Like the AWACS, the JSTARS communications suite provides a redundant communications capability as required in the C2 CFMP. The JSTARS maintains a dozen UHF radios, two HF radios, four VHF radios, and three SATCOM radios for secure voice and data. Additionally, the JSTARS is capable of JTIDS or Link-16 for secure communication with other airborne and ground assets. Like the AWACS, JSTARS uses one of its SATCOM radios for SIPRNET chat connectivity to communicate with coalition forces at the operational and tactical levels. The large number of voice and data communications allows the JSTARS crew members to communicate with many different joint and coalition forces simultaneously.[51] The JSTARS flies with a mission crew of approximately 18-34 Air Force and Army personnel divided into six functional areas: flight crew, technicians for radar and communications, surveillance personnel, weapons controllers, Army personnel, and an Airborne Intelligence Officer or Technician. The JSTARS aircrew can detect, track, and report ground movement to other airborne or ground assets simultaneously near real-time via LOS or BLOS voice or data communications. Like the AWACS, the close operating proximity of the JSTARS to the battlefield allows the JSTARS communications suite and aircrew to maintain the ability to relay information to various coalition forces on the ground or in the air even if satellite communications are interrupted. The JSTARS aircrew uses the extensive communications suite to generate, receive, access, correlate, fuse, combine, and disseminate sensor and TDL data to provide a comprehensive and accurate air and surface tactical picture to ATO participants, authorized users, and higher headquarters (HHQ) in accordance with the USAF's operational requirements.[52] Like the AWACS, the JSTARS must continue to modernize its fleet to ensure it can maintain interoperable

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[51] ACC/A8YB, unclassified E-8C capabilities briefing at the Moving Target Indicator Community of Practice at MacDill AFB on 22 February 2012.
[52] Ibid.

voice and data communications over the next 20 years.

JSTARS modernization to 2035

To extend the life of the E-8C, the USAF has assessed that new engines may be needed to ensure the aircraft can be sustained over the next 20 years.[53] This would also reduce maintenance costs, increase fuel efficiency, and optimize radar employment by allowing the E-8C to fly at a higher altitude to eliminate some radar screening issues associated with lower altitudes. At a cost of approximately $1 billion, the new E-8C engines would still not ensure the E-8C could meet future threats and requirements. Upgrading the JSTARS sensor is just as critical when operating in high threat environments.[54]

The AWACS and JSTARS have projected significant modernization or future upgrades to the aircraft and mission equipment over the next 20 years. However, a significant area lacking in modernization is the AWACS and JSTARS sensor upgrade. The AWACS and JSTAR sensor must also be upgraded to meet future challenges and threats.

AWACS and JSTARS modernization limitations

If the AWACS and JSTARS sensors cannot detect emerging threats, this places the E-3C and E-8C at risk for electronic attack and limits the Combined Forces Air Component Commander's (CFACC) ability to see and react to adversary air and surface actions in an A2AD environment or battlefield. The USAF FY10-15 Annual Planning and Programming Guidance (APPG) states: "Focus ISR recapitalization on gaps in the capability to detect, track, identify, and target high-stress targets such as Unmanned Aircraft Systems (UAS), cruise missiles, low-observable technology and theater ballistic missiles at tactically significant

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[53] ACC/A8Y staff interview with the author on 9 February 2012.

[54] Scott R. Gourley, JSTARS, retrieved from www.as.northropgrumman.com/…/6_7Gourley_JSTARS_0610.pdf. (Accessed on 9 February 2012)

ranges."[55] However, as highlighted above, the AWACS and JSTARS radars are currently not capable of detecting and tracking emerging low/very low RCS air and surface objects. Furthermore, there is currently no plan or funding to upgrade the radar to meet the APPG.[56]

Although there is no current plan to fund radar upgrades for the AWACS and JSTARS, the USAF FY 2010 C2 Capability Analysis Team Report (C2 CAT Report) identified several requirements for future airborne C2ISR Wide-Area Surveillance (WAS) sensors. The C2 CAT Report emphasized a need for next generation WAS sensors to conduct surveillance missions against current and future threats.[57] These threats include unmanned aircraft, cruise missiles, low-observable technology, and theater ballistic missiles. Furthermore, the C2 CAT Report highlights the necessity to acquire new sensor technology such as the AESA radar that will enable airborne C2ISR platforms to conduct the AMTI and GMTI missions simultaneously.[58] A multi-mission (AMTI and GMTI) platform using an AESA sensor can potentially provide a significant increase in capability for combatant commanders and helps to alleviate a low density/high demand situation that currently exists with single-mission JSTARS and AWACS airframes. There is a direct correlation between the size of an antenna and coverage area; therefore, depending on the size of the radar and platform, the AESA can significantly improve the range of coverage for AMTI and GMTI as well. In summary, the AWACS and JSTARS rely on older radar technology that is not as capable of detecting lower RCS threats vital in future conflicts and will require sensor upgrades to meet future operational

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[55] USAF FY10-15 Annual Planning and Programming Guidance (APPG) provided by USAF/A2C to author via e–mail on 12 February 2012.
[56] ACC/A8Y and SAF/AQI AWACS PEM discussion on AWACS and JSTARS modernization plans with author on Interview on 6 February 2012.
[57] AF/ GCIC/JIE, USAF FY 2012 Command and Control Capability Analysis Team Report 5 March 2009 provided to author via e-mail on 16 March 2012.
[58] Ibid.

requirements. In addition to aircraft capabilities, mobility is a key factor in determining overall capabilities of meeting operational requirements.

JSTARS and AWACS Mobility

The AWACS and JSTARS can deploy worldwide to most theaters but are limited to specific forward operating bases (FOB) due to runway size and threats to the aircraft.[59] To ensure 24/7 persistent C2ISR coverage in any theater, the following personnel manning, equipment, and logistical support is required to meet operational requirements:

At a minimum, the JSTARS and AWACS will be required to deploy at least 5 aircraft each to allow for adequate 24 hours/7 days a week airborne C2ISR coverage required during initial phases of a large-scale conflict. Three aircraft will usually fly 8-11 hour missions per ATO (Air Tasking Order) cycle to provide persistent 24-hour AEW coverage. The two additional aircraft are necessary for spare or replacement. Each platform will typically deploy with a 1 to 1.5 ratio of personnel. If each platform normally flies with twenty-two aircrew, a minimum of one hundred and ten aircrew would be required for a single deployment. For ground support, a total of sixty ground maintenance, life support, and other mission support personnel would be required to be in theater to support 24/7 operations. All of this assumes that the AWACS and JSTARS are deployed to a location with an operational wing infrastructure in place.[60]

RPAs and ISIS Capabilities Analysis

RPAs and unmanned airships may be able to support operational requirements for airborne C2ISR today. However, the differences in platform size, speed, range, and endurance will vary. Additionally, the sensor and communications suite will determine the number of platforms and methods of employment that will be required to meet the

[59] ACC/A8Y staff discussion with the author on 11 February 2012.

[60] ACC/A8Y staff on AWACS and JSTARS deployment requirements discussion with author on 19 February 2012.

operational requirements. These factors could result in considerably higher costs to maintain the same airborne C2ISR capability today. This section will analyze the VADER, DDR, RQ-4B Block 40 RPAs, and ISIS airship capabilities to determine whether or not they can meet airborne C2ISR operational requirements today. After assessing each system, this study will choose the two most capable platforms to compare capabilities and costs with the AWACS and JSTARS. Finally, this section will assess mobility requirements such as personnel manning, equipment, and logistical footprint associated with each system.

MQ-9 (VADER 4ft and DDR 6ft)

Aircraft

The VADER and DDR are MQ-9 medium-to-high altitude, long-endurance RPAs. The aircraft can fly at a max speed of 200 KTS, loiter at 50,000 feet, and fly up to 26 hours in duration. The long endurance and high altitude of the VADER and DDR provide great persistence and benefit to the sensor; however, the aircraft's slow speed when compared with the AWACS or JSTARS limits its ability to move quickly to a new tasking or to evade airborne threats. The VADER and DDR vehicles are operated via Line of Sight (LOS) or Beyond-Line-of-Sight (BLOS) with one pilot and one sensor operator. The USAF currently has 15 VADER and DDR aircraft in its inventory.[61]

Sensor for ISR

The VADER and DDR radar is capable of providing wide-area GMTI, small area GMTI, and SAR from approximately 60 km away from the target area. The VADER and DDR radar is significantly smaller than the JSTARS radar limiting its area of coverage. The maximum wide-area sensor coverage for the VADER and DDR radar is approximately 20 km x 20 km. When compared with the JSTARS wide-area coverage, VADER

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[61] ACC/A3C, unclassified MQ-9 VADER and DDR capabilities briefing dated September 2011 e-mailed to author on 6 February 2012.

and DDR can only provide a small "soda straw" look and would require many platforms to match the same Army Corps size coverage highlighted in the operational requirements. Exploitation of the VADER and DDR is conducted NRT by ground operators using remote operations video-enhanced receiver (ROVER) or VADER and DDR sensor operators located in a local ground station. The AF DCGS also has the ability to conduct the exploitation and correlation of GMTI, but other ISR sensor exploitation priorities and manning issues prevent them from doing so. The USAF would need to ensure the AF DCGS or other ground exploitation node conducts the NRT exploitation and correlation like the JSTARS aircrew does in the air.[62]

The Army has plans to purchase the VADER and DDR and will conduct NRT exploitation of these platforms in the Army's version of the Distributed Common Ground System known as DCGS-Army by 2013. These assets will provide the Army an organic GMTI platform operated at the Brigade Combat Team (BCT) level and below. The Army's plan to acquire the VADER and DDR is one of the reasons why the JSTARS Army personnel are leaving the JSTARS Air Force wing by October 2013.[63]

The DDR and VADER sensor is only configured for GMTI and does not have the ability to operate in AMTI mode. Additionally, in comparison with other RPAs and unmanned airships, the VADER and DDR have a very small wide-area surveillance capability due to the small size and power of the sensor. The limitation of aircraft size and power also impacts its ability to carry any communications equipment essential for BMC2.

Communications suite for BMC2

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[62] Ibid.
[63] Bryan Wutkis, U.S. Army Training and Doctrine Command (TRADOC) staff at Ft Huachucca in discussion with the author on 15 February 2012.

The VADER and DDR do not have a communications suite embedded on the aircraft to conduct the BMC2 mission. Additionally, the USAF does not have an integrated ground C2ISR infrastructure in place that would mirror or take over airborne C2ISR assets such as the AWACS and JSTARS. There are currently ground C2 nodes such as the CRC and ISR nodes such as the AF DCGS. However, the two do not currently mix. For the RPAs and unmanned airships to be utilized as integrated C2ISR assets, they would need a centralized ground C2ISR node to ensure the VADER and DDR could support the BMC2 mission.

The USAF should consider upgrading the AF DCGS with redundant LOS and BLOS voice and data communications to conduct both BMC2 and ISR missions simultaneously like the AWACS and JSTARS. The AF DCGS would need an additional 10 to 12 mission crew computers in order to be able conduct NRT AMTI/GMTI ISR and BMC2 operations.[64] This will allow the C2ISR operators to conduct exploitation and correlation of the sensor data as well as disseminate it to various entities via secure voice and data communications. Additionally, to ensure redundant LOS and BLOS communications requirements are met, at least one EQ-4 BACN would be required. Figure 1 below provides an example of how the C2ISR infrastructure and connectivity would look to ensure operational requirements are met. The diagram in figure 1 is interchangeable meaning any of the RPAs or unmanned airships can be substituted and support the concept of operations (CONOPS). Chapter 2 will consider the costs of upgrading and sustaining a modified AF DCGS to support the air and ground C2ISR structure and connectivity as illustrated in figure 1.

[64] Justin Gatchek, Electronic Security Command, Command and Control Battle Laboratory interview with author on 16 March 2012. The C2Battlelab was the lead office for developing and integrating the E-10A program.

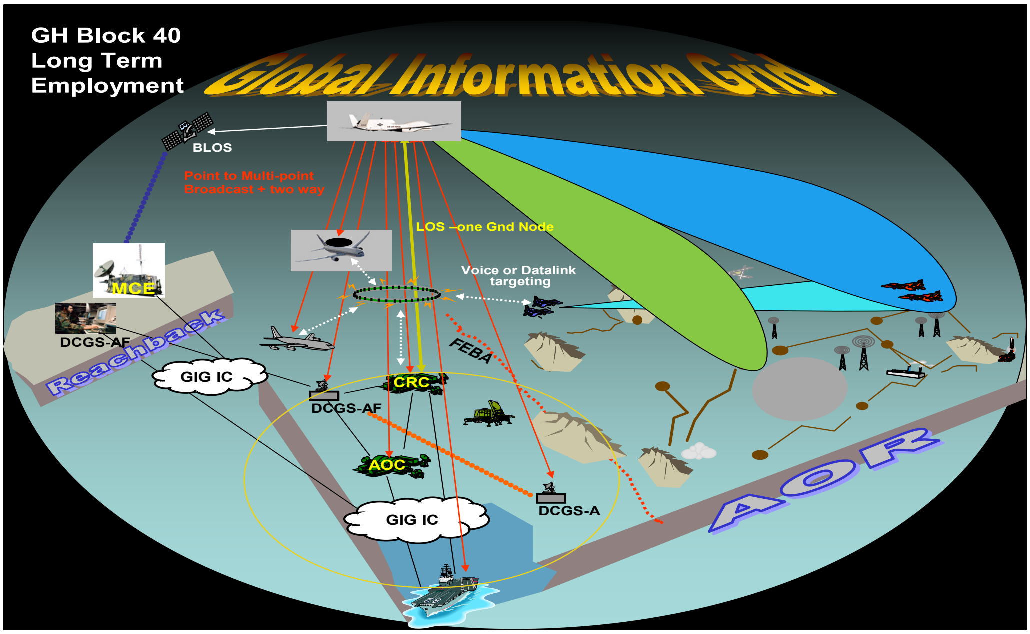

Figure 1: ISR and BMC2 connectivity with RPAs and ISIS

Source: Provided by ACC/A3C RQ-4B Block 40 enabling concepts

As mentioned above, figure 1 shows how a modified AF DCGS can bridge the C2 and ISR gap by integrating both BMC2 and ISR missions. Additionally, the AF DCGS provides a network for communications that make it less necessary to have LOS communications to conduct BMC2. For example, the RPA or unmanned airship would collect simultaneous AMTI/GMTI data in a specific area of interest. While these systems are collecting the data, they are simultaneously sending it to the AF DCGS via satellites or the EQ-4 BACN. The C2ISR operators in the AF DCGS would conduct the exploitation and correlation while disseminating the data via BLOS communications to various air and ground entities. Some military analysts believe that the C2ISR node must be able to communicate with air and ground assets using LOS secure UHF or VHF radios in the event LOS voice or data links are jammed or not operating. The C2ISR infrastructure ensures the EQ-4B BACN can provide

redundant BLOS and LOS communications.[65] Additionally, most air and ground coalition assets have the ability receive and transmit information directly via data links or relay through other entities. For example, if an RPA or unmanned airship is tracking vehicles on the ground and needs to communicate with any air or ground asset, the information can be sent from the AF DCGS to a DCGS-Army for relay to the relevant ground asset. At the same time, the information can be sent to an airborne strike asset via link 16 or secure voice. The BMC2 and ISR operations in support of AMTI/GMTI can be conducted simultaneously from a C2ISR ground node such as a modified AF DCGS; however, it will require a change to a more network-centric concept as illustrated in figure 1.[66]

Finally, as mentioned above, the VADER and DDR's slow aircraft speed, small wide-area GMTI coverage, and communications limitations do not allow these systems to meet the USAF operational requirements for airborne C2ISR. In a non-permissive environment, these systems would not be able to adequately provide GMTI coverage over hostile territory; therefore, they will not be considered for comparison against the AWACS and JSTARS platforms. The RQ-4B Global Hawk Block 40 and ISIS are more capable and suitable systems and will be examined next.

RQ-4B Global Hawk (Block 40)

Aircraft

The RQ-4B Block 40 is a high-altitude, long-endurance RPA capable of operating at 65,000 feet for up to 28 hours. The RQ-4B Block 40 has a maximum speed of 310 KTS and is designed to provide automated wide area surveillance coverage of up to 40,000 square miles per day. The RQ-4B Block 40 aircraft is operated via LOS or BLOS with one pilot and one sensor operator located in the launch and recovery

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[65] Capt Jay Vizcara, 53 Test and Evaluation Group, Det 1 discussion with the author on 22 March 2012. 53 TEG conducts development and operational testing of RQ-4B Block 40.
[66] Ibid.

element (LRE) and mission control element (MCE).[67] The USAF is scheduled to have 11 RQ-4B Block 40 aircraft in service by FY 2013.[68] The small number of RQ-4B Block 40s alone cannot provide adequate sensor coverage in multiple theaters critical to replacing the current AWACS and JSTARS force.

Sensor for ISR

The RQ-4B Block 40 aircraft is equipped with the MP-RTIP radar, an AESA radar with concurrent high-resolution AMTI, GMTI, and SAR modes in the X-band. The RQ-4B Block 40 aircraft is primarily dedicated to GMTI and SAR. However, recent developmental testing has shown that it is capable of conducting AMTI, GMTI, and SAR simultaneously.[69] The MP-RTIP radar can provide simultaneous AMTI, GMTI and SAR imaging while detecting targets at very low velocities and very small radar cross-section detection with high resolution and geospatial accuracy, and it can do this with persistence over the entire radar coverage area.[70]

The MP-RTIP radar is highly capable for AMTI. It can operate in two modes for AMTI: autonomous search and air track. Using operator-specified revisit rates, autonomous search enables the operator to search a volume of airspace designated by either a fixed reference volume or by a variable volume. The air track function encompasses several operating modes similar to fighter radar and can be interleaved into the search mode to track a target while it is scanning for more.[71] However, it is limited by its physical orientation on the aircraft. In AMTI mode, the MP-RTIP radar can only provide an air picture of 120 degrees field-of-view off

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[67] U.S. Air Force Fact Sheet for RQ-4B Global Hawk Block 40, http://www.af.mil/information/factsheets/factsheet.asp?id=13225.

[68] HAF/A2 RQ-4B capabilities briefing e-mailed to author on 6 January 2012.

[69] Capt Jay Vizcara, 53 Test and Evaluation Group, Det 1 interviewed by author on 22 March 2012. 53 TEG conducts development and operational testing of RQ-4B Block 40.

[70] Ibid.

[71] Ibid.

the beam of one side of the aircraft out to a distance of 100km.[72] Therefore, at least six RQ-4B Block 40 aircraft, along with ground-based radars, would be needed to ensure radar coverage equal to a single AWACS. The RQ-4B Block 40 alone cannot provide adequate coverage of AMTI due to the limitations of radar range and inability to fly over non-air permissive environments to extend the coverage. Ground-based radars such as the TPS-75 located at the CRC would fill in the gaps.[73] However, like the AWACS, it uses older radar technology compared with the AESA radar making it ineffective against fast, highly maneuverable stealth aircraft. The USAF is currently looking into upgrading the TPS-75 with new ground-based AESA radars called the Three-Dimensional Expeditionary Long-Range Radar (3DELRR).[74] Figure 2 below illustrates the RQ-4B Block 40 AMTI coverage in comparison to the AWACS. As mentioned previously, the ground-based radars such the TPS-75 would be required to fill gaps in coverage. Using figure 2 below, replacing the TPS-75 in the illustration would provide an example of how the RQ-4B Block 40 and TPS-75 would be employed together. Each RPA in figure 2 represents two aircraft. It would require many more RQ-4B Block 40's to replace a single AWACS alone. A significant limitation to the RQ-4B Block 40 is the 120-degree field-of-view and 100 km limitation in range. In a non-permissive environment, it will be difficult for the RPAs to achieve the same air surveillance look as a single AWACS.[75]

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[72] Ibid.

[73] USAF Command and Reporting Center (CRC) Fact Sheet retrieved from: http://www.552acw.acc .af.mil/library/factsheet.asp?id+14016. (Accessed on 4 May 2012) "The AN/TPS-75 Radar System ("Tipsy 75") entered service in 1968 and is a mobile tactical radar system capable of providing 3-dimensional, 360 degree coverage out to 240NM. It is located at the CRC and provides a "real-time" radar airspace picture and data in support of the Joint Forces Air Component Commander (JFACC).

[74] Justin Gatchek, Electronic Security Command, Command and Control Battle Laboratory interview with author on 16 March 2012.

[75] Capt Jay Vizcara, 53 Test and Evaluation Group, Det 1 discussion with the author on 22 March 2012. 53 TEG conducts development and operational testing of RQ-4B Block 40.

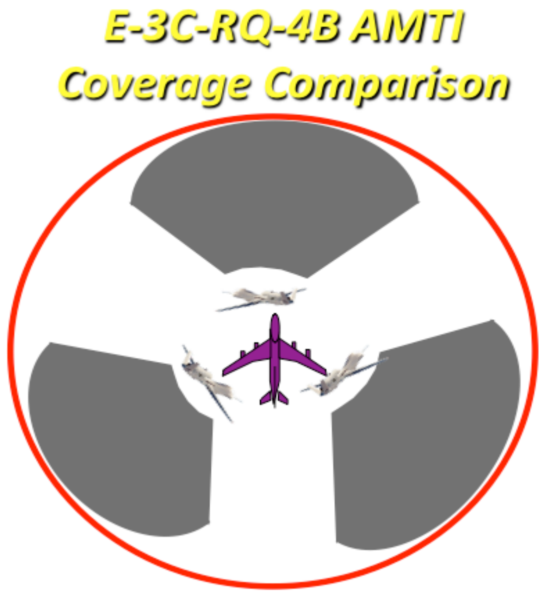

Figure 2: E-3C and RQ-4B AMTI Coverage Comparison

Source: Author's Original Work

Similarly, the RQ-4B Block 40 would need a six-to-one numerical advantage as well as the Army's organic GMTI platforms (like the DDR or VADER) over the battlefield to replace the JSTARS in GMTI and SAR modes. The MP-RTIP radar can provide high-resolution swath and spot imagery in SAR mode while providing GMTI wide-area surveillance. In the GMTI mode, the resolution, target location accuracy, and area of coverage can meet the USAF's operational requirements; however, the RQ-4B Block 40 would require at least six aircraft, in addition to the Army's organic GMTI platforms, to cover the same area as one JSTARS aircraft. The logic behind this is that one RQ-4B Block 40 can provide a 100 km x 100 km GMTI wide-area coverage at a stand-off range of approximately 100 km's away. Additionally, Army GMTI RPAs would likely be present on the battlefield to ensure a combination of the two service assets can cover an Army Corps size area.[76] Figure 3 below

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[76] Bryan Wutkis, Army Training and Doctrine Command, discussion with author on 11 February 2012 regarding Army's future GMTI platforms to complement the USAF's

illustrates the RQ-4B GMTI coverage in comparison with the E-8C. Each RQ-4B Block 40 represents two aircraft for a total of six aircraft providing AMTI and GMTI simultaneously. The RQ-4B Block 40 sensor data can be sent to the AF DCGS via SATCOM for NRT exploitation and correlation in conjunction with the BMC2 mission.

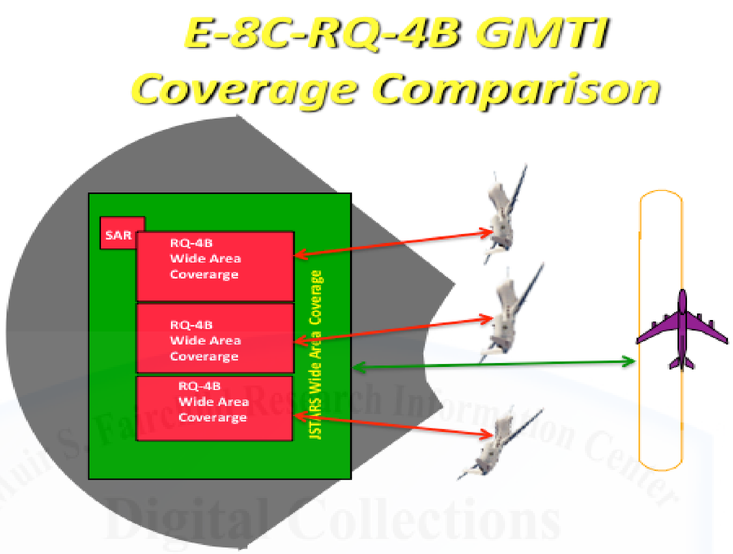

Figure 3: E-8C and RQ-4B GMTI Coverage Comparison

Source: Author's Original Work

Communications Suite for BMC2

The RQ-4B Block 40 would require the same communications infrastructure and connectivity as mentioned earlier and illustrated in figure 1. The next section will look at the RQ-4B Block 40 mobility to provide an estimate of aircraft, equipment, and personnel required for a deployment to meet USAF operational requirements.

RQ-4B Block 40 Mobility Requirements

The RQ-4B Block 40 has the ability to deploy worldwide to any theater and most forward operating bases (FOB) within hours. To ensure

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GMTI platforms reducing a single platforms requirement of covering an Army Corps size area.

24/7 (24 hours/7 days a week) persistent airborne C2ISR coverage in any theater, the following personnel manning, equipment, and logistical support would be required to meet operational requirements:

At a minimum, the USAF would be required to deploy at least eighteen RQ-4B Block 40 aircraft in addition to the Air Force's ground-based radars and Army GMTI platforms to allow for adequate 24/7 coverage equivalent to the AWACS or JSTARS. Eighteen aircraft would allow for six aircraft to fly one 24-hour mission per ATO cycle to provide persistent 24-hour Air and Ground Early Warning coverage. Another set of six aircraft would be required to relieve the aircraft going off station the following day, and the remaining six aircraft would be used as spares and replacement aircraft. Each platform would typically deploy with a 1 to 1.5 aircraft-to-crew ratio. If each platform normally flies with a crew of three, a minimum of 81aircrew would be required for a single deployment. For ground support, a total of sixty ground maintenance and other mission support personnel would be required to be in theater to support 24/7 operations. All of this assumes that the RQ-4B's are deployed to a location with an operational wing infrastructure in place.[77] In addition to the aircrew and ground crew associated with maintaining flying operations, twelve mission crew operators per 6 hour on station time and a modified AF DCGS for BMC2 would be required. A total of 48 mission crew operators would be required to provide a 24-hour ATO cycle in the early stages of a large-scale conflict. If the mission crew operators were assigned to an AF DCGS, they would not be required to deploy into theater like the AWACS and JSTARs aircrew. However, if they were attached to a CRC, they would be forward deployed. With that in mind, this paper focuses on upgrading an AF DCGS with BMC2 to reduce the number of deployed personnel and increase C2 and ISR integration. The next section will look at the ISIS capabilities. Many of the BMC2 issues

[77] ACC/A8Y discussion with the author on 10 February 2012.

and NRT exploitation issues will be similar to the RQ-4B Block 40.

ISIS (Integrated Sensor Is Structure)

The ISIS is a Defense Advanced Research Program Agency (DARPA) project and currently in the final stages of development.[78] It is expected to be operational in approximately two years.[79] DARPA started this program due to current gaps in wide area AMTI/GMTI surveillance and persistence from systems such as the AWACS, JSTARS, RPAs, and Space-Based Radar (SBR). The ISIS capability combines all four of these systems into a single airship.[80]

Integrated Sensor is Structure (ISIS)

Airship

The ISIS is a 100-feet long, lighter-than-air (LTA), airship that operates at 70,000 feet while staying airborne for 10 years at a time. The concept is similar to space assets as it is only launched once and remains on station at high altitude for many years. The ISIS airship loiters at very slow speeds, but it can relocate to any theater within 10 days.[81] According to DARPA, once the airship is placed in its operational orbit, very little maintenance is required for the platform. Additionally, the airship takes approximately 10 days to move from one theater to another. The exploitation concept of the ISIS sensor is similar to RPAs in that it would require an AF DCGS type of ground station to conduct the NRT exploitation and correlation with other ISR sensors.[82]

Sensor for ISR

The ISIS employs the AESA X-band radar and is capable of operating in both AMTI and GMTI modes simultaneously. In the AMTI mode, the radar can detect airborne targets out to 600km with a FOV of

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[78] Ibid.
[79] Tim Clark, DARPA ISIS briefing e-mailed to author on 9 February 2012.
[80] Ibid.
[81] Ibid.
[82] Timothy Tkacz, ISIS Project officer, DARPA discussion with author on 9 February 2012.

360 degrees. In the GMTI mode, the radar can also detect surface movers out to 600 km with a FOV of 360 degrees.[83] The key advantage to the ISIS radar is that it is significantly larger than any of the other systems. This allows a single ISIS airship to cover double the area of one AWACS and one JSTARS combined. Figure 4 and 5 below compares the ISIS AMTI and GMTI coverage with the AWACS and JSTARS. In addition to its large antenna size, the platform's slow speed is well suited for GMTI. The slow stationary position minimizes ground clutter interference which typically prevents conventional airborne radars from seeing slow-speed targets. The AESA radar also gives the ISIS the advantage in agility and track volume previously discussed. To provide adequate airborne early warning coverage for multiple theaters, homeland defense support, training and exercise support, a total of ten ISIS airships would be required. Having ten ISIS airships would adequately provide air and ground surveillance without the need for additional Army GMTI platforms or USAF ground based radars. It can potentially reduce the need for ground based radars that are a part of the CRC. Finally, it would allow four airships to remain stateside, two in the Pacific Command AOR, two in the European Command AOR, and two in the Central Command AOR. The sensor data would be transmitted via LOS or BLOS SATCOM data to various ground stations worldwide.

[83] Andre R. Maugeri, "DARPA's ISIS: Wide-Area Persistent Surveillance for the Future," Maxwell AFB, Alabama, June 2010, 16.

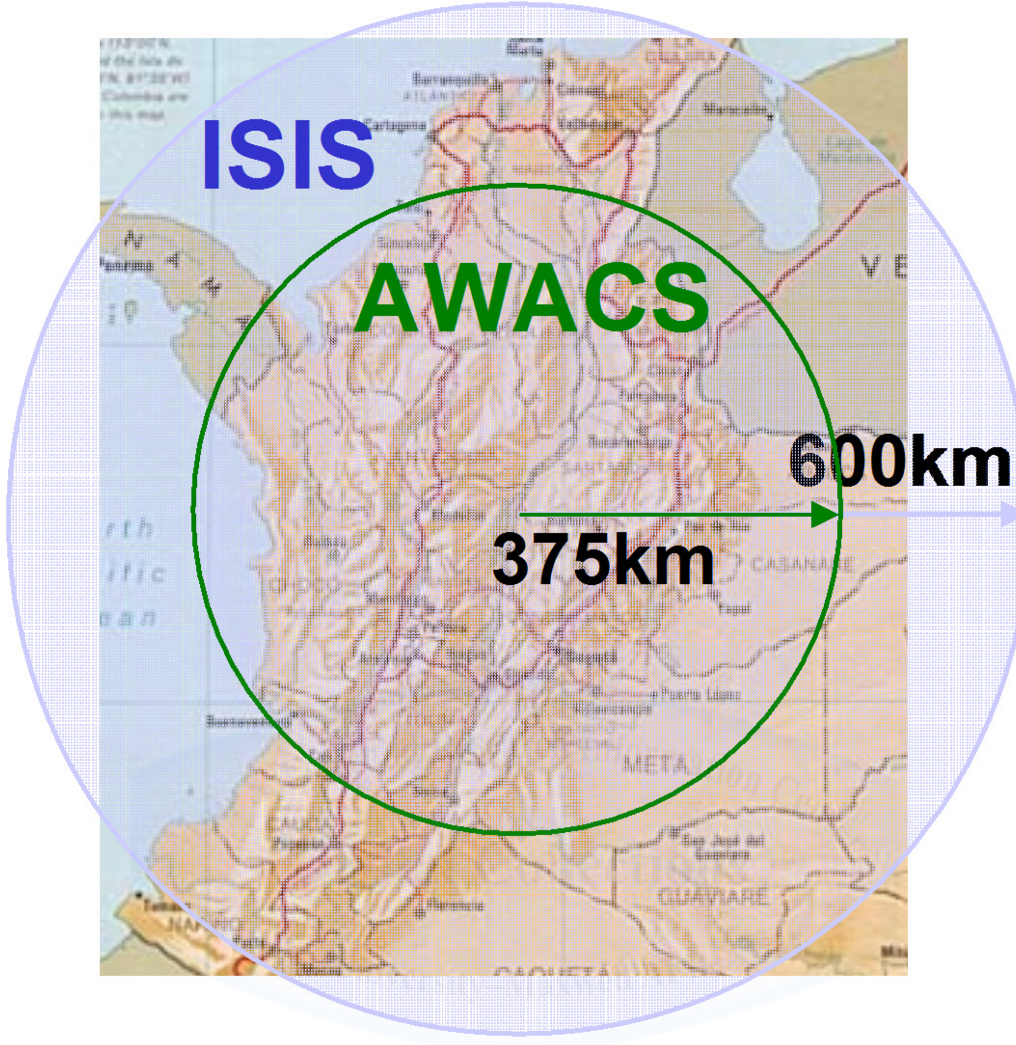

Figure 4: AWACS and ISIS AMTI Coverage Comparison

Source: ISIS Capabilities Briefing

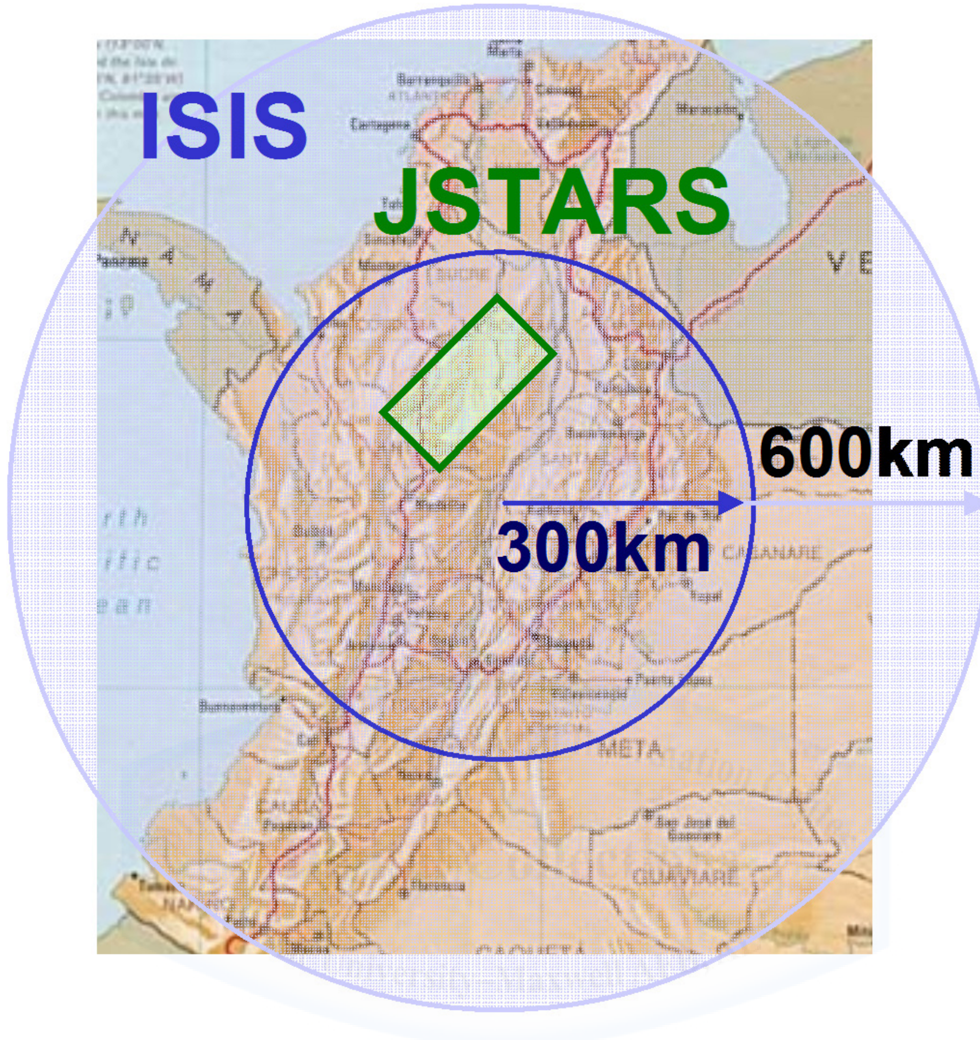

Figure 5: JSTARS and ISIS GMTI Coverage Comparison

Source: ISIS Capabilities Briefing

Table 1: Airborne C2ISR aircraft and personnel comparison

Per Unit	E-3C AWACS	E-8C JSTARS	RQ-4B Block 40	ISIS
Fuel	155000	155000	17300	N/A
Altitude (Ceiling (1Kft)	35	35	60	70
Speed (Knots)	390-510	390-510	310	N/A
Endurance (Hours and Years)	9-21 hours	9-21 hours	28 hours	10 years
Personnel (Aircraft and Mission Crew)	18-34	18-34	RPA crew 3 ISR node 48* BMC2 node12**	48* 12**
# Units	1	1	6	1

*Requires ground ISR exploitation node (AF DCGS) and personnel
**Requires ground BMC2 node (AF DCGS) and personnel
Source: Authors Original Work

Communications suite for BMC2

Like RPAs, the ISIS would require the same communications infrastructure and connectivity as mentioned earlier and illustrated in figure 1. The next section will look at the ISIS mobility requirements to provide an estimate of aircraft, equipment, and personnel required to meet USAF operational requirements.

ISIS Mobility

Unlike RPAs, the ISIS would not require any local infrastructure or personnel at the deployment location. Once the platform is launched, it would remain on station for approximately 10 years. The only costs associated with an ISIS would be the ISR exploitation and BMC2 nodes such as the modified AF DCGS indicated in figure 1.

The biggest advantage of the ISIS is the size of the airship and

advanced AESA sensor. Only one ISIS would be required to cover a single AWACS and JSTARS. That also means only one ISIS is need to cover a 24 hour ATO cycle for the AWACS and JSTARS. That makes it a 1:8 airship to aircraft ratio. Figure 6 provides a 24 hour coverage comparison of the various systems.

Similar to the RQ-4B Block 40, ISIS requires twelve mission crew operators per 6 hours on station time at the AF DCGS. A total of 48 mission crew operators would be required to provide a 24-hour ATO cycle in the early stages of a large-scale conflict. Chapter 2 will include the costs for including the ISIS mission crew into a modified AF DCGS.   The next section will provide an overall airborne C2ISR capability comparison.

Airborne C2ISR Capabilities Comparison

Using the data above, this section will compare the AWACS and JSTARS with the RQ-4B Block 40 and ISIS which have the most potential in replacing the two systems. As mentioned earlier, the VADER and DDR systems do not have adequate sensor size and power to meet operational requirements. The RQ-4B Block 40 and ISIS systems have the best potential for replacing the AWACS and JSTARS. The ISIS and RQ-4B Block 40 both employ the advanced MP-RTIP radar and can conduct both air and ground wide area surveillance simultaneously. This section will compare the systems in three distinct parts: the aircraft, the sensor for ISR, and the communications suite for BMC2. Additionally, this section will compare mobility requirements such as personnel manning, equipment, and logistical footprint associated with each system.

Aircraft Comparison

In comparison with the AWACS and JSTARS platforms, the RQ-4B Block 40 and ISIS platforms possess advantages and disadvantages. One obvious advantage is the absence of aircrew exposed to a high threat environment. For that same reason, they can also loiter longer

increasing the persistence of both air and ground surveillance. Another advantage the RQ-4B and ISIS have over the AWACS and JSTARS is the ability to operate at higher altitudes essential to maximizing sensor performance. Table 1 provides an aircraft and personnel comparison chart amongst the various systems indicating other areas that differ such as fuel consumption, range, and personnel.

The number of deployed operators required for the AWACS and JSTARS in comparison with the RQ-4B Block 40 and ISIS are significantly higher in numbers. For example, all of the AWACS and JSTARS aircrew would be required at a deployed location while the majority of the RQ-4B Block 40 and ISIS personnel would remain at their home station. The RPA aircrew numbers listed in table 1 show that three aircrew would be required to operate one RQ-4B Block 40. For a 24-hour ATO cycle day, a total of nine RPA aircrew would be required for a crew of three dividing the 24 hours into eight hours of operation for each crew. The 48 personnel listed in the RPA and ISIS section of table 1 are AF DCGS personnel that are already in place conducting ISR exploitation and correlation. The AF DCGS ISR crew of 48 and BMC2 crew of 12 are factored in per eight hours instead of per aircraft like the AWACS and JSTARS hard crew manning numbers. For example, if six RQ-4B Block 40's and one ISIS are airborne, a crew of 48 ISR operators and 12 BMC2 operators will be required for eight hours. However, since the AF DCGS is a separate ISR system exploiting many other intelligence sensors, it should not be counted specifically against the overall RQ-4B Block 40 and ISIS manning numbers. Only the twelve BMC2 operators and three aircraft operators should be factored in the equation. Therefore, for a 24-hour ATO cycle day, twelve BMC2 operators multiplied by three shifts of eight hours indicate that 36 total BMC2 operators would be required. Additionally, as mentioned above, nine RQ-4B Block 40 aircraft operators would be required bringing the total to forty-five RPA operators required for a 24-hour ATO cycle. Using the same logic, each AWACS and

JSTARS platform will require at least eighteen personnel per aircraft. Therefore, in a 24-hour ATO cycle day, 36 aircrew for both the AWACS and JSTARS would be required per a six hour on station time which makes it a total of 144 aircrew for a 24-hour on station time period.

Sensor for ISR Comparison

In comparison with the AWACS and JSTARS radars, the MP-RTIP radar employed on the RQ-4B Block 40 and ISIS presents a technology that is superior to the AWACS and JSTARS radars. The MP-RTIP radar can collect 600 more AMTI and GMTI tracks with a revisit rate six times faster than the AWACS and JSTARS radar.[84] The AESA technology also provides lower minimum detectable velocity, smaller radar cross-section detection, better resolution/geospatial accuracy, and track persistence over entire radar coverage area.[85] This enhances battlefield awareness and provides better support for advanced strike assets.

Unlike the AWACS and JSTARS' mechanical radars, the MP-RTIP radar is electronically scanned in both azimuth and elevation and can provide simultaneous updates in the AMTI, GMTI, and SAR modes. This means if the operator is looking at GMTI, and an interesting target requires further investigation, the platform can also provide a detailed SAR image without having to stop its GMTI service. Additionally, the resolution of the MP-RTIP radar provides greater fidelity and rapid update rates for better situational awareness. The computing power substantially increases the number of ground targets that can be tracked on the battlefield. In addition to GMTI, the MP-RTIP radar can employ focused AMTI mode to detect and track small radar cross-section, high-speed targets such as cruise missiles.[86] This is a critical capability that would enhance the USAF's ability to dominate in future A2AD

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[84] Tim Clark DARPA ISIS briefing e-mailed to the author on 9 February 2012.
[85] Ibid.
[86] George W. Stimson, *Introduction to Airborne Radar, 2nd ed.* (Raleigh, NC: SciTech Publishing Inc., 1998), 473.

environments highlighted in the DOD's strategic requirements and the USAF's operational requirements documents.[87]

One advantage the AWACS and JSTARS sensors have over the RQ-4B Block 40 is that they can provide greater coverage with fewer aircraft. Six RQ-4B Block 40's, accompanied with Army GMTI platforms and the CRC TPS-75 radar may be required to fill in gaps to cover one JSTARS and one AWACS together.[88] This is because a single RQ-4B Block 40 radar can only extend out to 100 km's making it difficult to provide adequate coverage in a non-permissive environment. Figures 2 and 3 provide an example comparing the AWACS and JSTARS with the RQ-4B Block 40 AMTI and GMTI sensor coverage area. Additionally, the AWACS and JSTARS can conduct NRT exploitation of the sensor data on board the aircraft and can communicate the data off board to strike assets faster than unmanned platforms.

On the other hand, the ISIS radar has a significant advantage over the AWACS and JSTARS sensor in the amount of area it can cover. Additionally, as shown on figure 6, only one ISIS is required to cover eight AWACS and JSTARS during a single 24 hour ATO cycle. Figures 4 and 5 show AMTI and GMTI sensor coverage area in comparison with the AWACS, JSTARS, and ISIS. Additionally, figure 5 shows how the ISIS is at an advantage over the JSTARS in any type of terrain and would be at an even greater advantage over a high-terrain environment like Afghanistan.

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[87] Defense Strategic Guidance, Global Leadershp: Priorities for 21st Century Defense, January 2012, www.defense.gov/news/Defense_Strategic_Guidance.pdf. 4, and BMC2 ISR CFMP.

[88] Capt Jay Vizcara, 53 Test and Evaluation Group, Det 1 interview by author on 22 March 2012. 53 TEG conducts development and operational testing of RQ-4B Block 40.

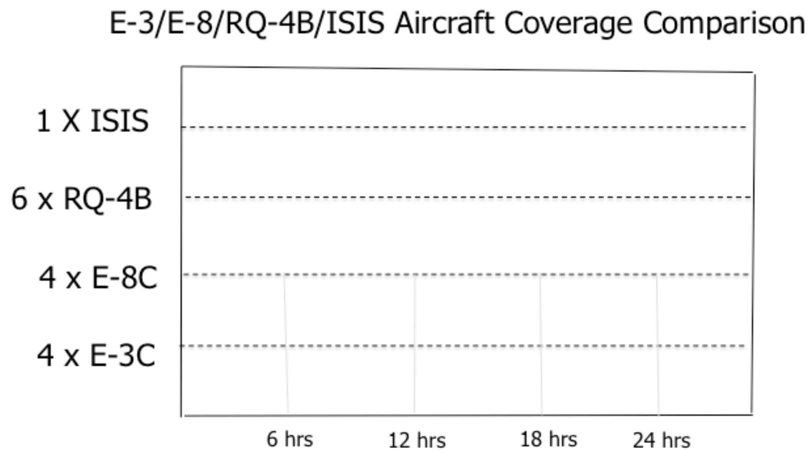

Figure 6: 24 hour E-3/E-8/RQ-4B/ISIS Coverage Comparison

Source: Authors Original Work

When considering whether or not to upgrade the AF DCGS to accommodate the AWACS and JSTARS for BMC2, one should consider the direction in which the USAF is headed. For example, the USAF has reduced future funding for the CRC and currently conducting studies on the future of the Theater Airborne Control System (TACS).[89] Additionally, the USAF leadership recently articulated the need for a leaner force.[90] Combining the AF DCGS to conduct BMC2 and ISR would make the USAF C2ISR force leaner and more efficient. Modifying the AF DCGS for BMC2 operations would require fewer personnel to be deployed in theater in comparison with the CRC. The AWACS and JSTARS mission crew operating the RQ-4B Block 40 and ISIS could be located within the AF DCGS at one of the 5 worldwide locations as a routine PCS assignment instead of a deployment with a forward-based CRC. Additionally, keeping the C2 and ISR personnel co-located at the AF DCGS would provide a more integrated approach to C2ISR. According to some AF DCGS experts, the BMC2 function can be easily

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[89]ACC/A8Y discussion with author on 10 February 2012.

[90] Secretary of the Air Force Michael B. Donley, United States Air Force Posture Statement 2013, Presentation to the Committee on Armed Services of the United States Senate, 20 March 2012. 1.

added to the existing AF DCGS infrastructure.[91] The only requirement would be additional rooms for approximately 12 commercial-off-the-shelf (COTS) computers and communications equipment. However, a change in C2 mindset, culture, and organization would be required and will be discussed in chapter 3. Chapter 2 will provide a break down of costs required for the BMC2 addition to the AF DCGS.

Table 2: Airborne C2ISR platform and ISR and BMC2 node comparison

System	Platform	Sensor	ISR and BMC2 nodes
E-3C AWACS	707-300	AN/APY-1/2	On-board
E-8C JSTARS	707-300	AN/APY-7	On-board
RQ-4B Block 40	Global Hawk	MP-RTIP	Off-board
MQ-9 VADER/DDR	Reaper	Lynx	Off-board
ISIS	Airship	MP-RTIP	Off-board

Source: Authors Original Work

Communications suite for BMC2 Comparison

The greatest advantage the AWACS and JSTARS systems have over the RQ-4B Block 40 and ISIS is the redundant communications suite for BMC2. Some Airmen claim the RPAs and unmanned airships questionable BMC2 capability is one of the factors making senior leaders reluctant to support the move towards an unmanned airborne C2ISR force. However, currently in the Central Command AOR, RPA assets like the EQ-4B BACN are demonstrating that it is possible to have communications redundancy using RPAs.[92]

The lack of BMC2 capability alone could be a showstopper in allowing RPAs and unmanned airships to replace manned airborne C2ISR platforms. As mentioned earlier, to effectively employ RPAs or unmanned airships in the BMC2 role, the USAF would need to either upgrade the CRC or AF DCGS to include the BMC2 equipment and

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[91] ACC/A2C AF DCGS representative discussion with author on 12 February 2012.
[92] Ibid. The EQ-4B BACN operates in the Central Command (CENTCOM) AOR and provides LOS and BLOS communications relay and gateway for many coalition air and ground assets.

personnel. In addition to BLOS SATCOM voice and data, the EQ-4B BACN must be a part of the CONOPS to ensure secure LOS voice and data communications exists in any AOR as illustrated in figure 1.[93] Because the EQ-4B BACN is already operational and a part of the communications infrastructure in some AORs, a separate cost estimate for this capability would not be required and not included in this study.

U.S. and Coalition air and ground assets must also be interoperable and train with this new operational concept to ensure BMC2 gaps are filled. Various nations rely on different types of communications equipment, and removing this capability from today's battlefield could undermine coalition effectiveness. On the other hand, as coalition forces move towards network-centric capabilities in the next 10 to 20 years, certain communications equipment may no longer be required.

Ultimately, the RQ-4B Block 40 and ISIS would operate within a net-centric construct enabling simultaneous communications/data exchange with multiple nodes, including battle managers, intelligence operators, and ground, airborne, and surface strike assets.[94] As mentioned earlier, figure 1 shows how RQ-4B Block 40 and ISIS would be integrated with ground ISR exploitation and BMC2 nodes to provide the same capability as the AWACS and JSTARS systems. Co-locating the BMC2 and ISR node using the AF DCGS would increase situational awareness and overall capabilities. However, heavy reliance on SATCOM for sensor data and communications can potentially make the MTI

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[93] Ibid. The EQ-4B BACN is a desirable capability even with today's systems. Some type of gateway/fusion node will be required no matter what systems we buy, because we're moving towards having an airborne IP network.

[94] Network-Centric Operations is an information superiority-enabled CONOPS that generates increased combat power by networking sensors, decision makers, and shooters to achieve shared awareness, increased speed of command, higher tempo of operations, greater lethality, increased survivability, and a degree of self-synchronization. In essence, NCO translates information superiority into combat power by effectively linking knowledgeable entities in the battlespace. U.S. Air Force Space and C4ISR CONOPS, Final, December 19, 2005, p. 6.

platforms vulnerable if the ground station loses satellite and EQ-4B connectivity.

Mobility Comparison

The RQ-4B Block 40 overseas footprint would not significantly differ from the AWACS and JSTARS requirements if the mission crew are located at a CRC. However, if the mission crew is co-located with the AF DCGS, it will significantly reduce the number of deployed personnel. Like the AF DCGS, the personnel assigned are stateside or overseas serving at their home station instead of being deployed. The RQ-4B Block 40 would require more deployed aircraft than the AWACS and JSTARS and may increase the number of maintenance personnel forward deployed.

The ISIS maintains a significant advantage over the AWACS and JSTARS because one ISIS airship can maintain radar coverage greater than one AWACS and one JSTARS together while staying airborne for 10 years. Maintenance and fuel costs are minimal, and the only personnel required to support the airship remain in the ground ISR exploitation and BMC2 node both located in the AF DCGS stateside.

Conclusion

It is technologically feasible to transform airborne C2ISR today. The RQ-4B Block 40 and ISIS have the ability to replace the AWACS and JSTARS now. However, it is not as simple as doing a one-for-one swap of platforms. Replacing the AWACS and JSTARS with the RQ-4B Block 40 alone would require far more aircraft than the USAF currently has or plans to purchase. Additionally, utilizing the Army GMTI platforms and the USAF's ground-based radar like the TPS-75 would be critical to filling gaps and ensuring airborne C2ISR operational requirements are met. Alternatively, the USAF could mix ISIS platforms with RQ-4B Block 40 platforms to provide a layered airborne C2ISR approach. This would also allow the new systems to monitor targets that are further away and with better persistence than the current AWACS and JSTARS force.

The MP-RTIP radar employed by the RQ-4B Block 40 and ISIS presents a technology superior to the AWACS and JSTARS. It has the ability to collect far more AMTI and GMTI targets, at a faster rate, while detecting lower RCS air and ground targets. This technology would be critical when operating against adversaries that possess stealth technology and weapons. Accordingly, the MP-RTIP radar coupled with a BMC2 and ISR node would be effective against most threats today and in the future.

To ensure BMC2 operational requirements are met, a BMC2 ground station is necessary. Upgrading the AF DCGS with a BMC2 capability would be a logical choice because it is a part of an established ISR infrastructure and would decrease the amount of personnel required to deploy forward. It will require some degree of risk such as relying heavily on SATCOM capabilities for connectivity. On the other hand, communications platforms such as the EQ-4B BACN operate in the CENTCOM AOR and have established a redundant LOS and BLOS capability. Additionally, the AF DCGS would increase C2 and ISR integration by co-locating and fusing these missions. The AF DCGS would only need to include BMC2 personnel, computers, and communications equipment to transform airborne C2ISR.

Transforming airborne C2ISR today with RPAs and unmanned airships now would put in palace a global C2ISR infrastructure that would be able to integrate future unmanned technology. Rather than replacing all systems at once, the USAF should start phasing out the AWACS and JSTARS while phasing in the RPAs and unmanned airships. To effectively transform airborne C2ISR the USAF should maintain at least twenty RQ-4B Block 40's to support training and deployment operations which require 18 RQ-4B's for a 24-hour ATO cycle coverage. However, this number would not be enough to support any homeland defense order if the United States is attacked. The USAF would need to

purchase ten ISIS airships to allow for adequate homeland defense, training at home station, and deployments to multiple theaters.

If the ISIS and RPA systems were both integrated in the new airborne C2ISR construct, the CRC may no longer be required to fill gaps. This would significantly decrease the number of Airmen deployed overseas. Finally, having both ISIS and RPAs integrated with a modified AF DCGS could provide greater C2 and ISR integration by fusing intelligence already being exploited from other sensors with AMTI and GMTI.

The next chapter will provide the life cycle cost estimate (LCCE) for each system. The LCCE for each system will include Research and Development (R&D), Operations and Maintenance (O&M), and Military Construction (MILCON) as sustainment and future equipment upgrades as modernization. In addition to analyzing the AWACS, JSTARS, RQ-4B Block 40 and ISIS modernization and sustainment cost, it will examine the modification and sustainment of the AF DCGS for BMC2 for the unmanned systems.

Chapter 2

Airborne C2ISR Cost Analysis

We can no longer afford expensive, incremental development of slowly evolving capabilities. We must revive the AF visionary culture, focus on realizing game-changing capabilities, make decisions and commitments to invest in the development of selected future game changers, and take calculated risks to ensure America's asymmetric warfighting advantage.

- General G. Michael Hostage III

The Air Force must balance risk by making choices now to either modernize and recapitalize an existing airborne C2ISR capability or transform it to conquer future threats and challenges. The previous chapter showed that it is technologically feasible to replace the AWACS and JSTARS with RPAs and unmanned airships today. However, there are some risks involved such as having a redundant voice and data communications capability as well as being too reliant on SATCOM for connectivity. On the other hand, replacing the AWACS and JSTARS with the RQ-4B Block 40 or ISIS would allow for greater sensor capabilities vital to operating in an A2AD environment. This chapter examines the life cycle costs of the AWACS, JSTARS, RQ-4B, and ISIS to determine which systems will be the most cost effective to maintain over the next 20 years. It argues that the up-front costs for transforming airborne C2ISR now will be greater than recapitalizing and modernizing the existing AWACS and JSTARS force; however, in the long term, the DOD will save more money and have a new C2ISR infrastructure in place to add future capabilities. The first section will examine the sustainment and modernization life cycle costs for the AWACS and JSTARS. It will then analyze the sustainment and modernization life cycle costs for the RQ-4B, ISIS, and modified AF DCGS for the BMC2 mission. The final section will compare and assess the overall life cycle costs against each system

to determine which C2ISR capability the USAF should pursue for the next 20 years.

Life Cycle Cost Analysis Methodology and Assumptions

Before examining the life cycle costs for the various airborne C2ISR platforms, this section describes the methodology and framework for comparing the costs. As mentioned, the overall study investigates whether or not airborne C2ISR should be transformed now based on capability and costs. One of the main differences in comparing the costs of new and existing systems over the next 20 years is the procurement cost. For example, the USAF will not acquire any additional or new E-3C and E-8C platforms. Therefore, procurement costs will not be factored into the analysis for the E-3C and E-8C. However, because these systems are old, recapitalization and modernization costs will be a significant strain over the next 20 years. In contrast, the RPAs and unmanned airships procurement costs will be factored in the analysis; however, modernization and recapitalization costs will be negligible because they are too new to need modernization and recapitalization.[1] Other differences in the cost analysis relate to the differences in each platform's sensor capability making the number of aircraft in each system different. Therefore, the study assumes the overall capability will be the same even though the amount of equipment differs. For example, 33 AWACS and 17 JSTARS aircraft will be compared against 20 RPAs and 10 ISIS.

This study will also include Research and Development (R&D), Operations and Maintenance (O&M), and Military Construction (MILCON) into the cost element. The R&D costs include non-recurring and recurring R&D costs for prototypes, engineering development and/or test hardware. The O&M costs will include mission personnel, depot maintenance, contractor support, and sustainment support. The

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[1] RQ-4B Global Hawk PEM and DARPA ISIS project managers stated that modernization costs for the RQ-4B and ISIS are unknown at this time.

MILCON costs include acquisition of resources necessary to provide facility requirements. These facility requirements include ground station facility upgrades necessary for successful development and operation of the capability. Additionally, this study uses FY10 dollar costs provided by the Air Force Total Ownership Cost (AFTOC) database. In addition to the sustainment and modernization costs, it considers the total number of years and flight-hours each aircraft is expected to fly. Since the ISIS is still in its development stage, it shows projected cost estimates provided by DARPA.

AWACS and JSTARS Life Cycle Cost Estimate

The AWACS and JSTARS platforms are aging and will need to be modernized and recapitalized to remain in service over the next 10 to 20 years. In addition to the modernization and recapitalization costs, this section will first look at the sustainment costs of each platform.

E-3C AWACS

Sustainment

The annual sustainment cost for the AWACS is approximately $872 million.[2] This estimate includes O&M and MILCON costs for 33 E-3C's worldwide and all Major Commands. The majority of the costs associated with the AWACS are related to O&M at approximately $327 million.[3] The sustainment cost is based on the E-3C's 4800 operational, test, and training flying-hours.[4] Figure 9 below provides a calculation of the sustainment cost for the next 20 years. To sustain the E-3C over this period will require modernization of the entire fleet.

Modernization

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[2] Air Force Total Ownership Costs (AFTOC) based on FY 10 E-3C sustainment costs retrieved from AFTOC database on 5 March 2012.
[3] Ibid.
[4] Ibid.

The modernization cost for the E-3C over the next 20 years includes upgrades to battle management tools such as computing and displays, combat identification, and data links. These upgrades contribute to network-centric operations by increasing combat identification through fusion with off-board air, ground, and space sensors. This $2.9 billion modernization plan is a part of the AWACS block 40/45 upgrade and is expected to extend the AWACS service life out to 2035.[5] Other costs for modernization will likely come up over the next decade as aviation and military technology evolves. This study assumes unforeseen costs due to opportunistic technology development will be equal across the options—any options may experience these.[6] Table 3 below provides a calculation of the sustainment and modernization costs for the next 20 years.

E-8C JSTARS

Sustainment

The annual sustainment costs for the JSTARS E-8C is approximately $550 million.[7] This estimate includes R&D, O&M, and MILCON costs for 17 E-8C's for both the Air National Guard and Active Duty element. The sustainment cost is based on the E-8C's 13,000 operational, test, and training flying-hours.[8] The sustainment cost for the JSTARS does not include any costs associated with the JSTARS Common Ground Station and Army personnel assigned to the JSTARS wing at Robins AFB, Georgia. This is because the Army is relocating their personnel from the JSTARS wing next year and transitioning their CGS to a DCGS Army construct. Like the AWACS, the JSTARS will

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[5] Brandice J. Armstrong, "General Bowlds, others discuss AWACS modernization project," 72nd Air Base Wing Public Affairs. (Accessed 20 January, 2012)

[6] AWACS Project Element Monitor (PEM) discussion with author on 11 February 2012.

[7] Air Force Total Ownership Costs (AFTOC) based on FY 10 E-8C sustainment costs retrieved from AFTOC database on 5 March 2012.

[8] Ibid.

require modernization and recapitalization to remain operational over the next 20 years.

Modernization

The E-8C cannot sustain itself nor maintain its current capability without modernizing its current fleet after 2020. This includes upgrades to the aircraft avionics, PME subsystem, and engines. According to ACC/A8Y, the E-8C fleet may need to replace its current TF-33 engines with newer JT8D-219 engines over the next 10 years if it plans to continue sustainment of the E-8C fleet over the next 20 years.[9] The remaining costs for the new E-8C engines include another $38 million to complete operational testing and at least $1 billion dollars to re-engine the entire fleet.[10] To ensure the E-8C is mission capable past 2020, the AN/APY-7 radar signal processor will require upgrades. The modernization costs for the PME are approximately $280 million.[11] Other areas of the PME such as the Surveillance and Control Data Link (SCDL), Integrated Broadcast System (IBS), and Blue Force Tracker (BFT) are desired, but not critical in remaining mission capable. The avionic modernization includes upgrades with the Flight Management System (FMS) and Control Display Units (CDU). The FMS/CDU's upgrades are critical to ensuring the E-8C fleet is mission capable past 2018. The cost for this upgrade is approximately $53 million.[12] Other avionic upgrades like Mode 5 IFF is desirable, but not critical. The cost for upgrading the entire E-8C fleet to Mode 5 IFF is approximately $228 million (FY10 dollars) and will be included in the cost analysis.[13] Figure 9 below provides a calculation of the JSTARS sustainment and modernization costs for the next 20 years.

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[9] ACC/A8Y staff interview with the author on 11 February 2012. Based on FY 10 dollars.

[10] Lt Col Ellis, Electronic Security Command, E-8C modernization briefing e-mailed to author on 26 January 2012. Based on FY 10 dollars.

[11] Ibid.

[12] Ibid.

[13] Ibid.

RQ-4B Block 40 and ISIS Life Cycle Cost Estimate

RQ-4B Block 40

Sustainment

The annual sustainment costs for the RQ-4B Block 40 is approximately $1.2 billion. This estimate includes R&D, O&M, and MILCON costs for 20 RQ-4B Block 40s worldwide and all Major Commands.[14] The majority of the costs associated with the RQ-4B Block 40 are related to procurement at approximately $608 million.[15] The sustainment cost is based on the RQ-4B's 1800 operational, test, and training flying-hours. The O&M cost for the RQ-4B is approximately the same amount as the E-3C and E-8C. However, the flying hours are significantly lower than the other two systems. Additionally, the R&D costs for the RQ-4B are $218 million.[16] The sustainment cost for the RQ-4B does not include the AF DCGS because it is a separate weapon system with its own budget and conducts exploitation for many other ISR sensors simultaneously. Finally, according to the RQ-4B Block 40 Program Element Monitor (PEM), there are currently no modernization or upgrades associated with the RQ-4B Block 40 as it has a life expectancy of 10 years. This is significant because the procurement cost will need to be factored into the overall cost every 10 years. Table 3 below calculates the RQ-4B Block 40 sustainment and modernization costs for the next 20 years.

Integrated Sensor is Structure (ISIS)

The ISIS is currently in its final stages of development, and the projected annual sustainment costs are estimated to be $650 million for 10 years due to procurement costs. The procurement cost for one ISIS airship is approximately $600 million. The estimated annual sustainment costs after the ten ISIS airships are acquired will be

[14] Air Force Total Ownership Costs (AFTOC) RQ-4B sustainment costs based on FY 10 dollars, retrieved by author from AFTOC database on 5 March 2012.
[15] Ibid.
[16] Ibid.

approximately $50 million. This estimate includes R&D, O&M, and MILCON costs for 10 ISIS worldwide and all Major Commands.[17] The sustainment cost for the ISIS airship is significantly lower due to the minimum maintenance required once the airship is launched. Like the RQ-4B, the ISIS life expectancy is 10 years. Therefore, the procurement costs for additional airships will be required 10 years after the In-Service Date (ISD). Currently, there are no projections for modernization costs associated with the ISIS. Table 3 below calculates the ISIS sustainment and modernization costs for the next 20 years. Finally, the ISIS and RQ-4B would require additional funding for the BMC2 ground station. This study will use the current AF DCGS sustainment costs to determine the estimated annual cost for the RQ-4B and ISIS BMC2 mission.

Modified AF DCGS for BMC2 Life Cycle Cost Estimate

The modified AF DCGS will require computers and communications equipment to provide effective BMC2 for the RQ-4B Block 40 and ISIS. This section will estimate initial costs to modify the current AF DCGS to accommodate 12 AWACS and JSTARS mission crew operators and equipment. Additionally, this section will provide an estimate for annual sustainment costs for the BMC2 portion of the AF DCGS.

Sustainment

The projected annual sustainment costs for the modified AF DCGS with BMC2 for the RQ-4B Block 40 or ISIS is approximately $150 million.[18] This estimate includes R&D, O&M, and MILCON costs for five AF DCGS's modified with the BMC2 capability worldwide and all Major

[17] Tim Clark, ISIS Project Manager, Defense Air Research Program Agency, ISIS Life Cycle Cost Estimate based on FY 10 dollars briefing e-mailed to author on 7 March 2012.

[18] Annual sustainment costs for AF DCGS based on FY 10 dollars provided by DCGS PEM and AF/A2RM on 27 March 2012.

Commands.[19] A large portion of the costs associated with the modified AF DCGS for BMC2 are the initial procurement cost at approximately $50 million for the first five years.[20] After five years, the sustainment costs are expected to decrease to $100 million.[21] These estimates are provided by the AF DCGS PEM and AF/A2RM based on the current AF DCGS sustainment and modernization costs. Like the RQ-4B Block 40 and the ISIS, there is currently no modification costs associated with the BMC2 ground station.

The annual sustainment and modernization costs in table 3 show that the RQ-4B would be the most expensive system to operate at $26 billion over the next 20 years. This figure does not include the cost for a modified AF DCGS for the BMC2 mission for both the RQ-4B and ISIS. An extra $3 billion would be required to transform all airborne C2ISR to the RQ-4B Block 40 and ISIS.[22]

Table 3: Sustainment and Modernization cost (FY2010) in millions

Source: Author's Original Work

System	Annual Sustainment Cost	Modernization Cost	Total Cost
E-3C AWACS	$872 Million x 20 years	$1.9 billion	$17.44Billion
E-8C JSTARS	$550 Million x 20 years	$1.3 billion	$11 Billion
RQ-4B Block 40	$1.3 Billion x 20 years	N/A	$26 Billion
ISIS	$650 Billion x 20 years	N/A	$13 Billion
Modified AF DCGS	$150 Million x 20 years	N/A	$3 Billion

Another way of comparing the cost for the airborne C2ISR systems is to examine the life cycle cost per flying-hour. For example, if one were to look at the average flying hours for a 20 year-period, one could compare each flight hour with each system. In addition, some systems

[19] Annual sustainment costs for AF DCGS based on FY 10 dollars provided by DCGS PEM and AF/A2RM on 27 March 2012.
[20] Ibid.
[21] Ibid.
[22] Based on FY10 dollars.

such as RPAs and ISIS are only projected to be operational for 10 years.[23] Accordingly, the life cycle cost will need to be doubled to project the RPA and ISIS costs for 20 years.

Assumptions and Calculations for Airborne C2ISR Costs Per Flight-Hour

This section will first determine the flight-hours by taking the average annual flight-hours and multiplying it by the remaining lifetime of the aircraft (20 years). For the JSTARS and AWACS aircraft this study uses the average flight-hour data recorded in AFTOC database from 1995-2008. The remaining lifespan assumption is 20 years for these two aircraft. The remaining flight hours for each AWACS is 14,600 and each JSTARS is 13,800 flight-hours. The estimated flight-hours remaining for each RQ-4B is 5,090 based on expected retirement date of 10 years and official USAF depreciation schedule.[24]

Table 4: Airborne C2ISR Platform Life Cycle Cost Per Flight-Hour

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[23] Tim Clarke, Defense and Research Program Agency, Project Manager for ISIS in discussion with author on 5 March 2012. JSTARS, AWACS, and RQ-4B Project Element Monitor (PEM) discussion with author on 11 February 2012.

[24] Tim Clark, ISIS Project Manager, Defense And Research Program Agency, ISIS Life Cycle Cost Estimate based on FY 10 dollars briefing e-mailed to author on 7 March 2012.

Aircraft	Life Span Flight hours	Total Life Cycle Cost	Life Cycle Cost Per Flight Hour
E-3 AWACS	14,600*	$2.7 Billion	$184,000
E-8 JSTARS	13,840*	$1.8 Billion	$130,000
RQ-4B	5,090**	$1.3 Billion	$255,000
ISIS	87,600**	$650 Million	$7420

Source: Author's Original Work

*E-3C/E8C Life Span Flight-Hours based on 20 years using average data from AFTOC

**RQ-4B/ISIS Life Span Flight-Hours based on 10 years using data from AFTOC and DARPA

The life expectancy for each ISIS airship is also 10 years with approximately 87,600 flight-hours. The total life cycle costs for these systems based on the previously mentioned costs are:

1) AWACS = Sustainment ($827M) + Modifications ($1.9B) =$2.7 Billion
2) JSTARS = Sustainment ($550M) + Modifications ($1.3B)=$1.8 Billion
3) RQ-4B Block 40 = Sustainment ($1.3B) + Modifications (0)=$1.3 Billion
4) ISIS = Sustainment ($650 M) + Modifications (0)=$650 Million

The life cycle cost per flight-hour in table 3 show that the RQ-4B is the most expensive system to operate. Additionally, this figure does not include the cost for a modified AF DCGS to conduct the BMC2 mission for both the RQ-4B and ISIS. Table 4 shows that an additional $150

million dollars per year will be required to maintain the BMC2 capability for these systems.

Life Cycle Cost Comparison and Analysis

The ISIS airship is the cheapest system to maintain over the next 20 years. The overall sustainment and modernization life cycle cost for the ISIS airship and modified AF DCGS BMC2 capability is approximately $16 Billion for the next 20 years. This estimate is a little more than half of the cost of both the AWACS and JSTARS systems combined. Additionally, the RQ-4B and modified AF DCGS BMC2 are roughly the same amount as the AWACS and JSTARS systems together. As mentioned in chapter 1, transforming airborne C2ISR with a mix of ISIS, RQ-4B Block 40, and AF DCGS would result in a more layered airborne C2ISR force. It may also reduce the need for maintaining a CRC due to the overlapping capabilities the RQ-4B and ISIS could provide. A detailed study of the future requirements and costs of the CRC is required to determine whether or not there is a need to maintain the capability based on emerging airborne C2ISR capabilities.

Conclusion

This chapter examined the life cycle cost for the AWACS and JSTARS compared with the RQ-4B Block 40 and ISIS. The life cycle cost analysis illustrated in Figure 9 showed that the upfront cost for the ISIS is more expensive when compared with the AWACS and JSTARS; however, the overall sustainment and modernization cost for the next 20 years is significantly cheaper than any other airborne C2ISR system. So far, this study has shown that the ISIS can provide more coverage with less aircraft as seen in Chapter 1. It also illustrated the benefits of mixing the ISIS with the RQ-4B Block 40 to enhance coverage and potentially reduce the need for other systems such as the CRC. A detailed study of the CRC costs and utility based on future airborne C2ISR capabilities is recommended. Chapter 2 indicated the ISIS and the modified AF DCGS life cycle cost for the next 20 years is significantly

less than the AWACS and JSTARS combined. Chapter 3 will examine the cultural implications of transforming airborne C2ISR today. It will identify the changes in organizations and concepts of operations (CONOPS) that may impact USAF interoperability with joint and coalition forces.

Chapter 3

Airborne C2ISR Transformation

> *Air Force Intelligence, Surveillance, and Reconnaissance cannot wait until new technologies are in place before transforming our organization, skills, and equipment.*
>
> - Lt Gen David A. Deptula

The USAF can improve joint and coalition warfighting capabilities today by transforming airborne C2ISR with newer and cheaper technology. However, this transformation will require Airmen to take risks as well as being open to new ideas. Chapter 1 revealed the differences in platform capabilities and concepts of operations (CONOPS). The increase in sensor capability and creation of a global C2ISR infrastructure provides a strong argument for transformation. On the other hand, communications risks make it difficult to take the leap of faith towards a new BMC2 approach. Other challenges involve organizational and cultural change. Initially, the transition will likely impact the culture, but the culture may also shape its implementation in ways that may in turn shape the technology in the long run. Would senior Air Force leaders and airborne C2ISR operators, with a proud warrior ethos, resist the change or embrace the opportunity to integrate the C2 and ISR mission on the ground? In theory, this transformation would result in significantly better C2 and ISR mission integration like the fusion of strike and ISR missions enabled by the MQ-1. But it can only succeed with the support of dedicated Airmen. This chapter will discuss the cultural implications involved in transforming airborne C2ISR. It will then analyze required changes in current C2ISR organizations and whether or not the USAF can remain interoperable with joint and coalition partners.

Cultural Change

The biggest hurdle in transforming airborne C2ISR is the cultural change involved in transitioning from manned to unmanned platforms and taking further steps to fuse intelligence and operations. A resistance to change a proud Air Force heritage and culture of flying can provide obstacles in taking advantage of new technology and capabilities today.

In *Medieval Technology and Social Change*, Lynn White states, "a new device merely opens a door, but does not compel one to enter."[1] The USAF will need to decide whether or not it will enter this door and explore new possibilities of "game changing" technology and CONOPS or continue fighting like it has over the last two decades in hopes that adversaries have not adapted to USAF doctrine and tactics, techniques, and procedures (TTP). Initially, the transformation of airborne C2ISR will likely impact the culture; however, in the long run, the culture may also shape the technology. During the early years of the remotely piloted aircraft (RPA) , the USAF was slow in adopting the use and integration of this new capability due to institutional bias against unmanned aircraft.[2] Once senior Air Force leaders embraced this technology, a RPA culture emerged. This UAV culture began as a non-kinetic ISR capability, but quickly evolved into a multi-role, strike and ISR, capability that exploited and advanced the development and employment of unmanned assets. These examples show how culture can shape technology. Furthermore, it demonstrates that an open mind and a willingness to blur the boundaries between intelligence and operations can provide positive operational and strategic effects.

Naturally, some Airmen worry about the USAF no longer needing humans to fly inside airplanes just as there are worries of automation or artificial intelligence replacing the need for humans to operate them from

[1] Lynn White Jr., *Medieval Technology and Social Change*, (Oxford University Press, 1962). 28.
[2] James Hasik, *Arms and Innovation,* (University of Chicago Press, 2008). 44.

the ground.[3] The current Unmanned Aerial System Flight Plan 2047 suggests that by 2030 flying robots could be programmed with "automatic target engagement" abilities.[4] For example, an unmanned aircraft that is pre-programmed to fly a certain mission may operate without a human in the loop during the entire mission. The unmanned aircraft could fly over a designated target or engage another "pop-up" or dynamic target after clearing a pre-programmed checklist of sensor data and preset rules of engagement. On the other hand, some USAF leaders at Creech AFB believe that human interface should always be required when involving death of human beings.[5] Many military analysts and officials use the case of the Patriot batteries that mistakenly fired and shot down coalition aircraft during Operation Iraqi Freedom as a reason for not relying on automation or artificial intelligence.[6]

Job security and moral issues are not the only reasons for resisting a cultural shift towards unmanned aircraft. Some analysts assess that the cultural resistance is similar to the Army's experience after World War I with the transitioning of the horse cavalry to the tank.[7] Many believe that Airmen value their proud aircrew identity and remotely piloted aircraft have taken away some of the identity and glory. For example, during combat missions in 2006, MQ-1 crews flew hundreds of hours tracking down and engaging al-Qaeda in Iraq. Because these Airmen were not physically flying over enemy territory, they were not

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[3] Based on personal experience and discussion with 116 Air Control Wing personnel. Many JSTARS personnel are worried unmanned systems will take over the JSTARS mission soon.

[4] United States Air Force Unmanned Aircraft Systems Flight Plan 2009-2047, Headquarters United States Air Force, Washington D.C., 18 May 2009. 50.

[5] Joe Pappalardo, "The Future For UAVs in the U.S. Air Force," Popular Mechanics, February 2010. http://www.popularmechanics.com/technology/aviation/military. (Accessed 15 May 2010)

[6] Ibid. During Operation Iraqi Freedom, Patriot systems set in automated modes engaged and shot down British GR-4 Tornado fighter aircraft killing two aircrew.

[7] David E. Johnson, Fast Tanks and Heavy Bombers: Innovation in the U.S. Army, 1917-1945," (Cornell University Press 1998). 125.

recognized or treated like aircrew that flew in combat.[8] Some aircrew that flew a few hours over Iraq and bombed targets were awarded the Distinguished Flying Cross, while others operating unmanned aircraft from stateside who spent many hours, even days, tracking the same targets were not recognized at all.[9] This mentality of not being recognized for flying in combat may be an obstacle in transforming airborne C2ISR. Monetary incentives may also be a factor in the resistance to change.

The AWACS and JSTARS mission crew consists of many air battle managers (ABM) previously not categorized as rated aircrew. This meant that ABMs were not eligible for aviation career incentive pay or flight pay equal to pilots and navigators. Additionally, ABMs were not required to actively fly for a certain amount of months (called gate months) to maintain an aeronautical rating. In an effort to retain and recruit more ABMs, the USAF gave ABMs rated status in October 1999. The ABM career field managers have made an effort to ensure officers maintain flying with the AWACS or JSTARS throughout their career.[10] Some military analysts argue that putting ABMs back on the ground would make it difficult to retain and recruit them. Additionally, there may be resistance to the change due to the desire to fly. However, many ABMs agree that as technology evolves, the need to have ABMs in the air will decrease just like any other aircrew.[11] Likewise, as airborne C2ISR related technology evolves, so will certain roles and missions.

P.W. Singer, in his book *Wired for War*, makes the case that technological advances can make certain roles disappear. He uses the example of the forward observers in battle. Forward observers were once

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[8] Major Dave Blair, "Ten Thousand Feet and Ten Thousand Miles," Air and Space Power Journal, May-June 2012, http://www.airpower.au.af.mil/article.asp?id=72, (Accessed 14 May 2012).
[9] Ibid.
[10] Adam J. Hebert, "Command from the Air," The Air Force Magazine, August 2003. 71.
[11] 116 Air Control Wing JSTARS personnel in discussion with the author.

military officers that required training and experience to call airstrikes from grids on a map, but the increase in technology, such as laser designators, have replaced the years of experience required.[12] Similarly, many manned ISR and fighter aircraft used in the non-traditional ISR (NTISR) role have been replaced over the last decade with RPAs such as MQ-1s and MQ-9s. These new systems have not dramatically impacted manning numbers in organizations, but they have reduced the number of personnel in harm's way and increased the duration of each ISR and strike mission. These systems have also blurred the lines between intelligence and operations.

As the boundaries between intelligence and operations become fuzzy, insecurities or "turf battles" emerge amongst organizations and missions that can hinder synergy amongst various capabilities. For example, the AWACS and JSTARS are considered C2ISR platforms; but for funding purposes, they are aligned under A-3 (Operations Directorate) as a C2 platform instead of A2 (Intelligence Directorate) for ISR.[13] This distinct cultural and organizational division has not allowed for improved C2ISR synergy and integration amongst the C2 and ISR community. A desire to keep the AWACS and JSTARS aligned under A3 and not A2 prevents this capability from reaching its full potential in mission integration. For example, the AWACS and JSTARS sensors can see air and ground activity from a stand-off range; however, they require off board sensors and intelligence to provide amplification to the unidentified targets they are tracking. Integrating the AWACS and JSTARS systems with other intelligence resources through the AF DCGS would provide increased combat identification and faster correlation of enemy movement and intentions. One may argue that data links such as JTIDS have filled the gap by providing increased situational awareness; on the contrary, combat identification can occur faster when

[12] Singer, P.W. *Wired for War*, (The Penguin Press 2010), 129.
[13] HAF/A2C discussion with author on 11 February 2012.

an experienced operator makes sense of diverse pieces of information and provides identification prior to the targets being entered into data links.[14]

At the operational and tactical level, the C2 and ISR community have greatly improved mission integration over the last decade, but there are still areas for significant improvement. Benjamin Lambeth makes the case that C2 and ISR integration challenges were overcome by what he refers to as "teaming." He articulates that the C2 and ISR community at the operational and tactical level came up with innovative ways to improve sensor integration and combat identification. For example, during the early days of Operation Allied Force, the JSTARS was typically thought of as a C2 platform, but as NATO Airmen looked for ways to integrate and team up the JSTARS with other ISR sensors like Unmanned Aerial Vehicles, NATO was able to enhance combat identification and produce more targets to prosecute.[15]

More recently, the JSTARS and AWACS have looked for ways to contribute to the ISR mission in Operation Enduring Freedom. Some military analysts say the presence of the CRC in Afghanistan and the lack of additional C2 mission requirements typically supported by the AWACS and JSTARS have made these assets look for ways to remain relevant in current operations. At the operational and tactical level, the AWACS and JSTARS are tasked and prioritized as an ISR asset. The Intelligence, Surveillance, and Reconnaissance Division (ISRD) in the Air Operations Center makes sure these assets are tasked to meet air and ground commander's intelligence requirements, yet they are often limited in their ability to provide needed intelligence due to sensor limitations and lack of other available ISR assets to be teamed up with them. In this

[14] Based on author's personal experience.
[15] Benjamin A. Lambeth, NATO'S Air War For Kosovo: A Strategic and Operational Assessment, Rand Study, 137.

case, SIPRNET chat or link 16 can provide situational awareness to various entities, but having a dedicated ground station such as the AF DCGS could provide faster and better intelligence. The AF DCGS could provide more proactive correlation of the AWACS and JSTARS data than it currently does because of the lack of current connectivity and focus resulting from insufficient integration and direction from higher levels of command. In this case, the need for integration of AMTI and GMTI with AF DCGS would need to be requested from the combatant commanders and implemented through the HAF/A2.

The USAF has recently experienced a significant cultural shift in how it views ISR. ISR is no longer viewed as a support function to operations—rather, ISR *is* operations.[16] The USAF needs to take further steps in integrating ISR with operations by making the term "C2ISR" a bigger part of the culture and organization. Accordingly, the USAF needs to continue its ISR cultural shift by fusing operations with ISR. This can be accomplished by removing the C2 and ISR cultural boundaries by integrating them together. Other services such as the U.S. Navy have begun to shift the intelligence and operations culture by merging the intelligence and command and control career fields.[17] Some military analysts believe that integrating the two core USAF competencies would result in better flexibility on the battlefield and timeliness of combat identification necessary to ensure decision-makers at the strategic, operational, and tactical levels of war receive the most accurate and fastest updates of the enemy situation. Additionally, merging the two would ensure that C2 and ISR are integrated at the highest level so that

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[16] Deptula and Brown, A House Divided: the indivisibility of ISR.

[17] Robert K. Ackerman, "Navy Builds around Intelligence, Information Consolidation," SIGNAL Magazine, May 2010, http://www.afcea.org/signal/articles/templates/Signal_Article_Template.asp?articleid=2282&zonid=254.

C2 and ISR operators at the operational and tactical levels do not have to continue to create ways to integrate two "stovepipe" systems.[18]

But the technology is also forcing tough choices about how to provide the ISR. The Navy is in the process of modernizing its airborne C2ISR fleet with brand-new P-8 Poseidon platforms. General (Ret) Ronald Fogleman, former Chief of Staff of the Air Force, recently said, "The Air Force should decide if it's serious about "big" intelligence, surveillance, and reconnaissance aircraft in its fleet, and should either step up or step back and let the other services take over the mission. The ISR mission is not an Air Force birthright."[19] Michael Wynn, former Secretary of the Air Force, states, "In a future era, where the air domain is disputed, can we really risk the large, populated C2ISR airplanes when we actually have penetrating stealthy aircraft with better radars and "multi-intelligence" devices, and the 3-digit surface-to-air missiles are valid to 200 to 300 miles?"[20] He believes the USAF should retire the AWACS and JSTARS platforms for new systems. Secretary Wynn articulates a valid point in that the USAF must be able to operate in future A2AD environments without risking large loss of life and capability. Many observers have argued the need for large aircraft even when the intelligence community has proven the ability to process intelligence from across the globe using reach back with capabilities like the AF DCGS.[21] The words of General Fogleman and Secretary Wynn

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[18] Lt Col (Ret) Alex Wathen, "Joint Airspace Management and Deconfliciton: A Chance to Trade in a Stovepipe for Network-Cenric Warfare," Air and Space Power Journal, Fall 2006. Stovepipe is a metaphorical term used by many military professionals to describe how an organization or system is developed in isolation or is narrow minded or lacks integration with other systems.

[19] Gen Ronald Fogleman speech at the AFA's Mitchell Institute for Airpower Studies in Arlington, VA on Wednesday, 11 April 2012.

[20] Colin Clark, "Scrap AWACS, JSTARS; Plough dough into F-35, Wynne says," DOD BUZZ Online Defense and Acquisition Journal, 31 January 2011. Retrieved from http://www.dodbuzz.com/2011/01/31/scrap-awacs-jstars-plough-dough-into-f-35/ on 16 March 2012.

[21] Amy Butler, "OSD Eyes E-10A As Possible Billpayer For Attack Drone Program," *Defense Daily*, 5 December 2003, Vol. 220, Issue 44.

both provide a wake-up call for the USAF in that it must decide how it will move forward. Should the USAF continue to fund and operate large high-risk platforms or invest in new technology that could change the U.S. military's approach to airborne C2ISR? Some military analysts believe the problem is that the USAF is still too focused on platforms and not capabilities. For example, when the USAF looks at future air and ground surveillance capabilities, they frequently refer specifically to follow-on AWACS and JSTARS platforms instead of an integrated systems or capabilities approach that improves air and ground surveillance. These are difficult questions and topics that will likely impact the USAF's organization and infrastructure in the near future.

Organization and infrastructure

As technology and missions evolve, so will the structure of the Command and Control, Intelligence, Surveillance, and Reconnaissance enterprise of the United States Air Force. Therefore, we need an organization and infrastructure that can adapt to the information age capabilities of today and the future.

As technological advances occur, unmanned platforms will likely replace manned airborne C2ISR platforms. However, transforming airborne C2ISR now will not result in drastic changes to the C2 organizations and infrastructure at Tyndall, Tinker, and Robins Air Force Bases. The mission and training at these locations would likely experience a gradual transition as seen recently with total force integration (TFI) at Robins AFB over the last decade.

The Undergraduate Air Battle Manager training conducted at the 325th Air Control Squadron at Tyndall AFB prepares future CRC, AWACS, and JSTARS mission crew operators for BMC2 and ISR missions in ground training facilities. Air Battle Manager (ABM) officers get oriented in Basic Flight Maneuvers (BFM) and learn to provide control to

aircraft. It also prepares them for future airborne and ground C2ISR missions with the CRC, AWACS, and JSTARS. The training facilities at Tyndall AFB consist of air and ground control simulators used to train operators in procedural control and "radar scope interpretation," also known as RSI for airborne and ground radars. Mid-grade leaders at Tyndall say replacing the AWACS and JSTARS today would not change or significantly impact the organizations' training or structure.[22] On the contrary, they claim integrating RPAs and unmanned C2ISR platforms at the ABM schoolhouse would introduce training and qualification in specific weapon systems earlier than they are currently introduced. Currently, ABM students receive basic training and orientation on the AWACS and JSTARS at Tyndall, but students do not receive initial qualification training (IQT) and certification on these weapon systems until they arrive at the AWACS or JSTARS units. Transforming airborne C2ISR would allow for greater flexibility by allowing ABMs to be certified on AMTI and GMTI platforms prior to arriving at Robins and Tinker AFB.[23]

The JSTARS unit at Robins AFB consists of both Active Duty (AD) and Air National Guard (ANG) wings responsible for executing airborne ground surveillance missions. Transforming airborne C2ISR and replacing the JSTARS with RPAs or unmanned airships may decrease the morale of JSTARS aircrew. On the other hand, maintenance crews would likely remain unaffected by the change. The overall numbers of personnel at Robins AFB could decrease as certain aircrew and ground crew positions are no longer needed. However, the majority of the airborne operators, maintenance, and support personnel would likely be needed to support the new aircraft and ground stations.

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[22] Major Aaron "Vandal" Gibney, former Assistant Director of Operations, 325th Air Control Squadron and Major Mike Hagen, future Director of Operations, 325th Air Control Squadron, Tyndall AFB in discussion with the author on 3 May 2012.
[23] Ibid.

The JSTARS wing is very familiar with organization and cultural change due to its recent experience with blending AD and ANG members from two separate weapon systems. In October 2002, the Georgia ANG B-1B wing and AD JSTARS wing blended together a diverse group of personnel and mission experience to form a Total Force blended wing. Many military analysts felt that the organization and infrastructure could not support the change and diversity; but the transition was successful due to dedicated AD and ANG personnel.[24] Many B-1B aircrew were very disappointed about not being able to fly "sexy" bomber aircraft; however, many embraced the change for new leadership opportunities.[25] Like the JSTARS wing, the AWACS wing would also be able to provide a smooth transition in the airborne C2ISR mission.

The AWACS wing at Tinker AFB is similar to the JSTARS wing, but with an air surveillance mission focus. The transformation of airborne C2ISR would create similar challenges of changing the current aircrew warrior ethos; however, it would not drastically change the organization or infrastructure at Tinker AFB. Like the JSTARS, the majority of operations personnel are mission crew. The 552 Air Control Wing maintains both airborne surveillance capabilities with the AWACS and overseas ground-based air surveillance capabilities with the CRC that is conducted at Luke AFB. The unique combination of the two missions would provide familiarity to the Airmen at Tinker due to the similarities of the mission crew concept in the air and on the ground. From a maintenance perspective, the number of personnel would likely not change depending on the number of RPAs or ISIS assigned to the unit. However, if the USAF decided to only replace the AWACS and JSTARS with ISIS, it would significantly decrease the number of maintenance personnel at Robins AFB and Tinker AFB. The biggest organizational

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[24] Lt Col Jeffrey A. Herd, "The Fully Integrated Wing (AC/ANG)-Does the Air Force Have it Right?" Research Project, U.S. Army War College, March 2006, 3.
[25] Based on authors personal experience.

change would be related to the forward-deployed airborne C2ISR units. Transforming airborne C2ISR would reduce the number of forward-deployed support personnel and aircrew. The majority of the personnel would be located either stateside or at overseas bases in AF DCGS type of units.

There are currently five AF DCGS units around the world conducting exploitation for each COCOM.[26] These units provide IQT and MQT to support various operations. Integrating the RPAs and ISIS AMTI and GMTI/SAR data into the AF DCGS would be not be difficult to accomplish at current AF DCGS sites around the world. The big challenge would be integrating the BMC2 mission into the AF DCGS architecture. BMC2 operators would either need to be co-located at each AF DCGS or geographically separated in locations such as Tinker AFB and Robins AFB. One solution is to build two more AF DCGS sites at Tinker AFB and Robins AFB. This move would enable the USAF to better integrate AMTI and GMTI within the AF DCGS while increasing the USAF's NRT ISR data exploitation and correlation capabilities—shortfalls for which the USAF has been criticized in the past.[27] Adding two more AF DCGS sites with an AMTI and GMTI/SAR exploitation and correlation focus would increase the overall analytical capability currently lacking in these disciplines. Integrating the C2 and ISR career fields and units as previously mentioned would significantly bridge the C2 and ISR gap at many different levels.

At the strategic level, C2ISR integration would increase the focus on improving future C2ISR capabilities rather than platforms. Having a

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[26] Capt Sean Piccirilli, HAF/A2RM, AF DCGS capabilities briefing provided via e-mail to author on 16 March 2012.

[27] The AF ISR community has been criticized for focusing too much on ISR sensors and not enough on analytical tools to exploit the enormous amounts of data collected by the sensors. Amber Corrin, "Sensor overload: Military is dealing with a data deluge," Defense Systems, 4 February 2010 article retrieved 0n 16 March 2012 from http://defensesystems.com/articles/2010/02/08/home-page-defense-military-sensors.aspx.

true C2ISR architecture would decrease costs and single intelligence or "INT" stove pipes that the AWACS and JSTARS have experienced with AMTI and GMTI. At the operational level, C2ISR integration would provide operational level commanders with faster correlation of INT and more NRT analysis of sensor data essential to operational level decision-makers. At the tactical level, C2ISR integration would improve situational awareness of friendly and enemy forces to tactical-level assets. In addition to improving C2ISR integration in the USAF, it is critical to understand how transforming airborne C2ISR would impact interoperability with joint and coalition forces. It is also important to understand the direction in which U.S. allies such as the U.K. and NATO C2ISR community are heading. The next section will examine how transforming airborne C2ISR could impact concepts of operation and interoperability with joint and coalition forces.

Concepts of Operations

Transforming airborne C2ISR now would not significantly change airborne C2ISR Concepts of Operations (CONOPS) from an ISR perspective; however, it will change CONOPS from a C2 perspective as C2ISR operators would be geographically separated from the battlefield as highlighted in Chap 1.

The USAF would task the RQ-4B Block 40 or ISIS to deploy to a theater of conflict like the AWACS and JSTARS are today. These airborne C2ISR systems would be tasked to support a wide range of operations including major combat operations like global strike, global persistent attack; military support to stabilization, security, transition and reconstruction operations; and homeland security. The Combined Forces Commander (CFC) would delegate operational and tactical control of these airborne C2ISR systems to the Combined Forces Air Component Commander (CFACC), just as he does with AWACS and JSTARS. These airborne C2ISR systems would receive formal tasking from the ATO and SPINS, and the CFACC would exercise unity of command and centralized

control through the JAOC. The RQ-4B Block 40 and ISIS would directly support the CFC and CFACC by conducting BMC2 and ISR as directed to provide Indications and Warnings (I&W) for Intelligence Preparation of the Operational Environment (IPOE) before hostilities commenced. Once combat operations commenced, the CFACC would continue to determine the objectives and priorities based on warfighting requirements. The BMC2 and ISR exploitation node or AF DCGS would control the execution of the mission. Joint strike assets and other support assets would not perceive a change as data and voice links would be used to communicate to the various entities.[28]

Joint and Coalition Interoperability

General Norton Schwartz, Chief of Staff of the Air Force, states that "Active collaboration between our services will reveal untapped synergies in key areas such as intelligence, surveillance, and reconnaissance; electronic warfare; command and control; and building and sustaining fruitful international partnerships with U.S. allies, partners and friends."[29] Shifting the USAF's airborne C2ISR focus from being platform-centric to capabilities-centric would enable the joint forces to continue improving the network-centric capabilities they started developing in the late 1990's. The 2012 USAF posture states "No longer in a Cold War technological environment, the Air Force is transforming its C2 to an internet protocol-based network-centric war fighting capability. To do so, the Air Force must sustain, modify, and enhance current C2 systems, and develop deployable, scalable, and modular systems that are interoperable with Joint, Interagency, and Coalition

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[28] Air Combat Command, RQ-4B Block 40 (MP-RTIP) enabling concept, March 2008 provided by ACC/A3C via e-mail, 16 February, 2012.

[29] General Norton A. Schwartz, and Admiral Jonathan W. Greenert, "Air-Sea Battle: Promoting Stability in and Era of Uncertainty." The American Interest, February 20 2012.

partners."[30] The Army, Navy, and Marine Corps are also moving in the same direction to ensure cross-domain cooperation.

One example of cross-domain cooperation between the Navy and Air Force relates to airborne C2ISR research and development. The Air Force and Navy are currently working with the Defense Advanced Research Agency (DARPA) on future Bi-Static unmanned aerial vehicle (UAV) prototypes. The Bi-Static is a very small UAV capable of operating in non-permissive environments. In theory, it would be able to significantly expand air surveillance coverage of the E-3, E-2, and TPS-75 radar. It is also likely to serve as a communications repeater like the EQ-4B BACN while operating over hostile territory. There is very limited information on this R&D prototype, but this would be a significant capability to add to the airborne C2ISR force once it has been tested.[31]

In addition to R&D initiatives, each service provides unique operational ISR capabilities and continues to work together to collect, fuse, and share accurate, timely, and detailed intelligence.[32] Some military analysts see network-centric warfare as a vulnerability of the U.S. military because it relies heavily upon satellite communications for connectivity. This becomes a great concern when operating in contested or A2AD environments. Other analysts believe the U.S. military should learn to fight without satellites.[33] The DOD is actively looking for ways to develop other communications alternatives so the USAF would not be heavily reliant upon satellite connectivity in the future. Like the U.S.

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[30] Secretary Michael B. Donley and General Norton A. Schwartz, Fiscal Year 2013 Air Force Posture Statement presentation to the committee on Armed Services United States House of Representatives, 28 February 2012, 22.

[31] Air Force Magazine, "Air Force eyes Bi-Static approach to air surveillance, October 2011, http://www.airforce-magazine.com/DRArchive/Pages/2011/October%202011 /AirforceEyesBi-staticApproachtoAirSurveillance.aspx. (Access 12 December 2011) No other information on open source available to the author.

[32] Department of Defense (DOD) Joint Operational Access Concept (JOAC) Version 1.0, 17 January 2012, 29.

[33] Phillip C. Saunders and Charles D. Lutes, "Motivations and Implications," Joint Forces Quarterly, issue 46, 3rd quarter 2007, 49.

joint community, coalition partners such as NATO and the U.K. C2ISR community would continue to remain interoperable through software and hardware compatibility.

Maintaining airborne C2ISR interoperability with NATO and the U.K. is critical to military operations in support of Afghanistan and future contingencies. This section will examine future NATO and U.K. airborne C2ISR plans and determine the impact transforming airborne C2ISR will have on interoperability with coalition forces.

The NATO AWACS fleet currently maintains 17 E-3A aircraft that are similar to the USAF E-3C with regards to aircraft, ISR sensor, and BMC2 communications suite. In 2008, the NATO AWACS Component completed a mid-term $1.6 Billion upgrade for avionics, Prime Mission Equipment (PME) software and computer processors for all 17 aircraft. This upgrade is expected to keep the NATO AWACS fleet in service beyond 2035.[34] In addition to these upgrades, the NATO AWACS Component is taking the initiative to improve C2 and ISR integration by developing new hardware and software capable of fusing off-board Electro Optical/Infrared (EO/IR) imagery with the NATO E-3A AMTI to positively identify (PID) targets and improve situation awareness.[35] This initiative is integrating and fusing C2 and ISR much like the transformation of USAF airborne C2ISR would. Transforming USAF airborne C2ISR today would not impact interoperability with the NATO AWACS because of the compatibility of communications. For example, the NATO AWACS and AF DCGS would maintain redundant connectivity through SATCOM voice and data as well as other links such as Link-16

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[34] NATO Ops Wing Test and Evaluation, Geilenkirchen, Germany, NATO E-3A Component mid-term upgrade briefing provided via e-mail to author on 11 April 2012.

[35] John Mahaffey, "AWACS Rising-Joint C2ISR: Force Multiplier for the 21st Century," The Journal of the Joint Air Powre Competence Center, Edition 15, Spring/Summer 2012. 30.

using NATO STANAG 4607.[36] Figure 7 provides an illustration of the NATO AWACS and NATO Alliance Ground Surveillance (AGS) connectivity with USAF airborne C2ISR assets.

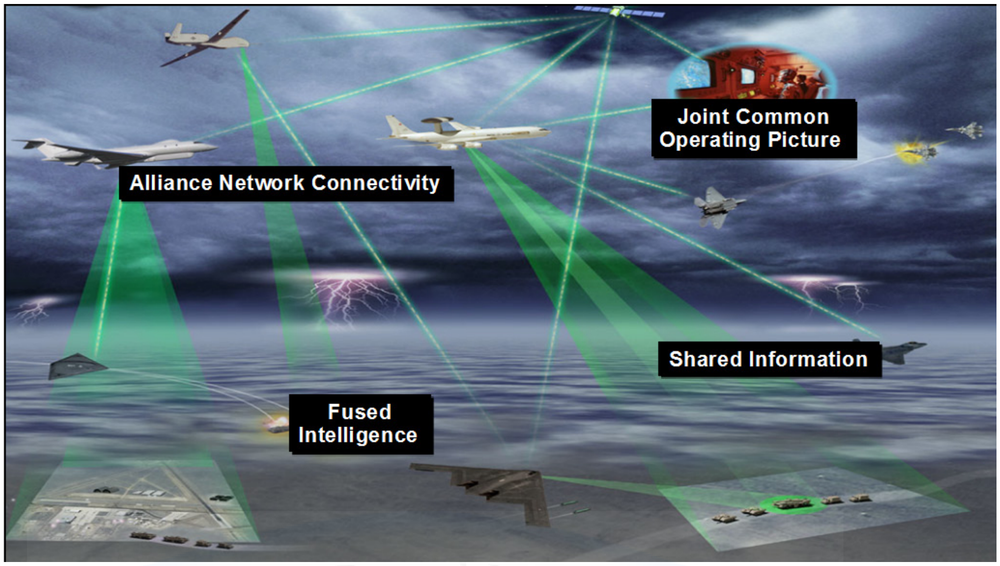

Figure 7: NATO and U.K. Air and Ground Surveillance
Source: NATO E-3A Capabilities Briefing Illustration

The NATO AGS program started out with a similar "large manned aircraft" concept like the U.S. JSTARS and E-10A program. Due to funding constraints, NATO decided to pursue RPAs for ground surveillance similar to the USAF's RQ-4B Block 40. The NATO AGS is also based on a RQ-4B aircraft called the "Euro Hawk" and employs the MP-RTIP sensor for ISR. The NATO AGS aircraft and ground station will be located at Sigonella, Italy. USAF airborne C2ISR interoperability with the NATO AGS would involve connectivity amongst the various AGS ground stations and AF DCGS.[37] Like the NATO AWACS, the primary

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[36] STANAG 4607 is "NATO Ground Moving Target Indicator Format (GMTIF). The format provides a flexible format for target information so that GMTI systems can exchange data on specific targets. The format provides GMTI and other systems to see target information such as location and radial velocity. NATO Intelligence, Surveillance and Reconnaissance (ISR) Interoperability Architecture (NIIA) AEDP-2, September 2005.

connectivity between the USAF airborne C2ISR force and the NATO AGS would be via SATCOM data and voice along with Link-16. The NATO AGS is currently in its final development and testing stage and expected to enter service in 2015.[38]

The U.K. Royal Air Force (RAF) maintains 7 E-3D AWACS for air surveillance. The overall capability of the E-3D is similar to both the USAF E-3C and NATO E-3A. USAF airborne C2ISR interoperability with the RAF E-3D would remain unchanged because of the current network-centric capabilities in place. The USAF would continue to maintain interoperability through SATCOM data and voice as well as Link-16. The U.S. and U.K. C2ISR community has participated in network-centric warfare trials over the last decade to enhance sensor fusion and correlation. Much of this work was conducted via Link-16 and would continue to provide connectivity through the AF DCGS.[39] Similar to the USAF's DCGS, the U.K. is developing their own DCGS to conduct ISR exploitation of their MQ-1 and MQ-9's. The RAF DCGS will also provide ground exploitation for their Sentinel R-1 ground surveillance platform.

The RAF maintains 5 ground surveillance aircraft known as the Sentinel R-1. This system has been in service since 2006 and is similar to the JSTARS in that it provides ground situation awareness to air and ground commanders through GMTI and SAR analysis; however, it is not capable of conducting BMC2 on-board the aircraft due to communications and aircrew limitations. The BMC2 for the Sentinel R-1 is conducted off-board by the RAF E-3D crew.[40] The USAF and RAF currently maintain a JSTARS and Sentinel interoperability Program (JSIP) and have ensured that information can be exchanged by SATCOM

[37] John Kriendler, *NATO Intelligence and Early Warning,* Watchfield, UK: Defence Academy of the United Kingdom, Conflict Studies Research Centre, 2006, 3.
[38] NATO AGS briefing retrieved on 20 April from http://www.nato.int/cps/en/natolive/topics_48892.htm.
[39] Sqn Ldr Mike Lyttle, Royal Air Force, Air Warfare Center, Air C2ISR Operational Evaluation Unit Flight Commander interviewed by author on 20 April 2012.
[40]Ibid.

voice and data as well as Link-16.[41] The USAF's transformation of airborne C2ISR would require the NATO and U.K. C2ISR community to understand and train with the USAFs new C2ISR construct; however, it should continue to be interoperable in the future.

Conclusion

Transforming USAF airborne C2ISR today would likely require a change in culture, organization, and CONOPS to enhance interoperability with joint and coalition forces in the future. The airborne C2ISR culture may have to refocus to forge a true C2ISR community focused on capabilities rather than platforms.

Initially, the transition would likely impact the culture, but the culture would likely shape the technology in the long run as it did with the armed RPAs. The cultural implications of implementing these ideas would likely deliver positive operational and strategic effects. Employing airborne C2ISR operators in ground stations instead of in the air may create some initial resistance due to a proud aircrew identity; however, the new mission sets could create greater opportunities for air battle managers and surveillance technicians by bridging operations and intelligence missions. It may also open the door for other mission sets not yet identified. Integrating C2 and ISR at the highest levels of the USAF would reduce stovepipes by making sure that air and ground surveillance capabilities are integrated into a global C2ISR infrastructure like the AF DCGS. Additionally, Airmen at the operational and tactical levels would not have to look for innovative ways to integrate separate C2 and ISR capabilities during operations like OAF and OEF.

The organization and infrastructure at Tyndall AFB, Robins AFB, and Tinker AFB would also change to accommodate the new aircraft and ground stations. Two new AF DCGS sites would enhance the C2ISR enterprise's overall analytical capability by conducting NRT AMTI and

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[41] Lt Col Herb Maraman, JAIP Tiger Team lead interviewed with author on 20 April 2012.

GMTI exploitation. Finally, transforming airborne C2ISR today would continue to enhance joint and coalition C2ISR interoperability through various communications software and hardware compatibilities.

Conclusion

> *We are shaping the Air Force today to ensure its strength tomorrow. In the future, the Air Force will be leaner but will remain fully effective at any size maintaining agility, flexibility and the readiness necessary to engage a full range of contingencies and threats.*
>
> \- Secretary of the Air Force Michael B. Donley

Over the last decade, the USAF has been looking for follow-on platforms to replace and transform the current airborne C2ISR force. The USAF has studied the feasibility of using space-based radar (SBR) platforms as well as large manned aircraft like the E-10A to meet USAF C2 and ISR operational requirements. Neither of these platforms met the operational requirements and has forced the USAF to continue relying on the E-3C AWACS and E-8C JSTARS for airborne C2ISR. These platforms are based on 50+year old Boeing 707 airframe with older radar technology. The current airborne C2ISR force was designed to operate in the Cold War environment and should be replaced with newer technology to negate modern, emerging threats. However, does the technology exist today? If so, what are the costs and benefits of transforming airborne C2ISR, and should the USAF transform airborne C2ISR now?

The USAF must make strategic choices today by weighing the costs and the benefits of replacing or modernizing the current airborne C2ISR force. This study revealed that it is technologically feasible to replace the AWACS and JSTARS today with RPAs and unmanned airships. However, replacing one C2ISR system for another is not a simple one-to-one platform replacement. Replacing these systems would require a transformation of airborne C2ISR by moving away from a Cold War platform-centric C2ISR force to a new information age capabilities-centric C2ISR force. The upfront costs for replacing the AWACS and JSTARS with RPAs and unmanned airships would be higher, but the long-term

costs would be lower. Even if the costs of transforming airborne C2ISR were significantly lower than modernizing the current force, this transformation would require Airmen to embrace technology, cultural changes, and innovative ideas to enhance interoperability with joint and coalition forces.

Capabilities Analysis Summary

This study used the C2 and GI ISR CFMP as well as USSTRATCOM's desired MTI and SAR attributes and capabilities as a framework to determine operational requirements for airborne C2ISR. It showed that the RQ-4B Block 40 and ISIS have the ability to replace the AWACS and JSTARS ISR capabilities today. However, it is not a simple one-to-one replacement of platforms. Additionally, replacing the AWACS and JSTARS with the RQ-4B Block 40 alone would require far more aircraft than the USAF currently has or can afford to purchase. The RQ-4B Block 40 would need to utilize the Army's organic GMTI platforms and the USAF's ground-based radars to fill gaps in AMTI and GMTI coverage. A better solution to transforming airborne C2ISR would be to mix the ISIS with the RQ-4B Block 40 to provide a layered airborne C2ISR approach. The RQ-4B Block 40 and ISIS employ the MP-RTIP radar that presents a technology superior to the AWACS and JSTARS. In addition to the greater sensor range, it has the ability to collect far more AMTI and GMTI targets at a faster rate while detecting lower RCS air and ground targets. This technology would be critical when operating against adversaries that possess advanced stealth technology.

The RQ-4B Block 40 and ISIS would need to be coupled with improvements to ground nodes like AF DCGS to provide both BMC2 and ISR. Upgrading the AF DCGS with a BMC2 capability would also provide increased integration between C2 and ISR roles while decreasing the amount of personnel that would be required to deploy forward. However, it would require some degree of risk such as relying heavily on SATCOM capabilities for connectivity. On the other hand, communications

platforms such as the EQ-4B BACN operating in the CENTCOM AOR today have established a redundant LOS and BLOS capability and would reduce the risks of losing connectivity at all levels of war.

To effectively transform airborne C2ISR, the USAF would need to maintain twenty RQ-4B Block 40's. This would allow an adequate number of aircraft to support training and deployment operations that require eighteen RQ-4B's for a 24-hour ATO cycle coverage. However, this number would be insufficient to support any homeland defense order if the United States was attacked. The USAF would need to purchase ten ISIS airships to allow for adequate homeland defense, training at home station, and deployments to multiple theaters. Finally, if the ISIS and RPA systems were both integrated in the new airborne C2ISR construct, the CRC may no longer be required to fill in gaps. This would significantly decrease the number of Airmen deployed overseas and potentially reduce costs.

Cost Analysis Summary

This study provided a holistic look at the costs involved in either modernizing the current airborne C2ISR force or transforming it with new capabilities. It included Research and Development (R&D), Operations and Maintenance (O&M), and Military Construction (MILCON) into the cost element. The R&D included non-recurring and recurring R&D costs for prototypes, engineering development and/or test hardware. The O&M factored in mission personnel, depot maintenance, contractor support, and sustainment support. The MILCON costs included acquisition of resources necessary to provide facility requirements. These facility requirements provided a cost for ground station facility upgrades necessary for successful development and operation of the capability. The FY10 dollar costs used in the analysis was provided by the Air Force Total Ownership Cost (AFTOC) database. In addition to the sustainment and modernization costs, it considered the total number of years and flight-hours each aircraft is expected to fly.

The ISIS is still in its development stage and used projected cost estimates provided by DARPA.

The life cycle cost comparison showed the ISIS is the cheapest system to maintain over the next 20 years. The overall sustainment and modernization life cycle cost for the ISIS airship and modified AF DCGS BMC2 capability is a little more than half of the cost of both the AWACS and JSTARS systems combined. Additionally, the RQ-4B and modified AF DCGS BMC2 are roughly the same amount as the AWACS and JSTARS systems together. The life cycle cost analysis illustrated in table 3 shows that the upfront cost for the ISIS is greater than the cost for AWACS and JSTARS; however, the overall sustainment and modernization cost for the next 20 years is significantly less than that for any other airborne C2ISR system. Additionally, this study showed that the ISIS provides more AMTI and GMTI coverage with fewer aircraft as seen in Chapter 1.

It also illustrated the benefits of mixing the ISIS with the RQ-4B Block 40 to enhance coverage and the potential reduced need for other systems such as the CRC. The USAF should conduct a detailed study on the CRC's utility and costs based on future airborne C2ISR capabilities

Even with the life cycle costs of transforming airborne C2ISR being lower than modernizing the current force, the biggest hurdle in transforming airborne C2ISR today is changing the institutional mindset, culture, and organization to allow the USAF to conduct airborne C2ISR differently than it has over the last two decades.

Culture, Organization, and Interoperability Analysis Summary

Transforming airborne C2ISR today would arguably impact the overall C2ISR culture and organization in positive ways that would enhance interoperability with joint and coalition forces in the future.

Initially, the transformation would impact culture, but in the long run, the culture may also shape the technology. The biggest challenge in implementing this new C2ISR capability is moving the air and ground

surveillance operators to a ground station thousands of miles from the battlefield. A proud aircrew identity may cause resistance towards the change unless new opportunities and incentives are in place. Providing them with better combat recognition and expanding their opportunities to integrate with various ISR disciplines, other than just AMTI and GMTI, may be a step in the right direction. A closer C2 and ISR relationship at the Air Staff level would forge a true C2ISR community that would likely have positive implications at the operational and tactical levels.

The organization and infrastructure at Tyndall AFB, Robins AFB, and Tinker AFB would also change to accommodate the new aircraft and ground stations. Two new AF DCGS sites would enhance the C2ISR enterprise's overall analytical capability by conducting NRT AMTI and GMTI exploitation and correlation.

Joint and coalition forces continue to improve C2ISR capabilities that have positively impacted interoperability amongst services and countries. Coalition partners such as NATO have recently moved towards fusing C2 and ISR on-board the NATO AWACS. Similarly, the U.K. Sentinel R-1 has changed its approach to C2ISR operations by allowing the U.K. AWACS to conduct BMC2 using data collected by the Sentinel R-1 platform. Finally, transforming airborne C2ISR today would continue to enhance joint and coalition C2ISR interoperability through various communications software and hardware upgrades.

Conclusion

The USAF cannot afford to sit back and wait until the current airborne C2ISR force is obsolete and no longer capable of contributing to the joint and coalition fight. Transforming airborne C2ISR today with a mix of RQ-4B Block 40 and ISIS would complement and create an infrastructure that can integrate new unmanned technology in the future. The USAF should start phasing out the AWACS and JSTARS while phasing in the RPAs and unmanned airships. The USAF should transform airborne C2ISR now to reduce costs and depart from the Cold

War construct. Transforming the airborne C2ISR force will have positive strategic effects by changing Cold War era culture, operational concepts, organization, and technology to negate 21st Century threats.

Acronyms

A2AD	anti-access area denial
ABM	Air Battle Manager
ACC	Air Combat Command
AD	Active Duty
AESA	active electronically scanned aperture
AEW	Airborne Early Warning
AFB	Air Force Base
AF DCGS	Air Force Distributed Common Ground Station
AFTOC	Air Force Total Ownership Costs
AMTI	Air Moving Target Indicator
ANG	Air National Guard
AoA	Analysis of Alternatives
AOC	Air Operations Center
AOI	Area of Interest
AOR	Area of Responsibility
APPG	Air Planning Program Guidance
ASTOR	Airborne Stand-Off Radar
ATO	Air Tasking Order
AWACS	Airborne Warning and Control System
BACN	Battlefield Airborne Communications Node
BFT	blue force tracker
BFM	basic flight maneuvers
BLOS	beyond line-of-sight
BMC2	Battle Management Command and Control
C2	command and control
C2C	Command and Control Constellation
C2CAT	Command and Control Combat Assessment Team
C2ISR	Command and Control Intelligence, Surveillance, and Reconnaissance
CAOC	Combined Air Operations Center
CDL-MLDSTD	common data link military standard
CDU	control display unit
CENTCOM	Central Command
CFACC	Combined Forces Air Component Commander
CFMP	Core Functional Master Plan
CMD	cruise missile defense
COCOM	Combatant Commander
CONOPS	concept(s) of operations
COTS	Commercial Off-The-Shelf
CRC	Command and Reporting Center
CRRA	Capabilities Review and Risk Assessment
DARPA	Defense Advanced Research Program Agency

DCA	Defensive Counter Air
DDR	Dismount Detection Radar
DoD	Department of Defense
DPG	Defense Planning Guidance
EA	electronic attack
EO	electro-optical
ESA	electronically scanned array
ESM	electronic support measures
F2T2EA	Find, Fix, Track, Target, Engage, Assess
FL	flight level
FMS	flight management system
FOB	forward operating base
FOV	field of view
FY	fiscal year
GATM	Global Air Traffic Management
GMTI	Ground Moving Target Indicator
GPS	Global Positioning System
IBS	integrated broadcast system
HD/LD	high demand/low density
HF	High Frequency
HHQ	Higher Headquarters
HRR	high range resolution
IADS	Integrated Air Defense System
ICD	Initial Capabilities Document
IFF	Identification of Friendly or Foe
IQT	initial qualification training
IR	infrared
ISAR	inverse synthetic aperture radar
ISD	In-Service-Date
ISIS	Integrated Sensor Is Structure
ISR	intelligence, surveillance, and reconnaissance
I&W	indications and warnings
JAOC	Joint Air Operations Center
JFACC	Joint Force Air Component Commander
JMMA	Joint Multi-Mission Aircraft
JROC	Joint Requirements Oversight Council
JSTARS	Joint Surveillance Target Attack Radar System
JSIP	JSTARS-Sentinel Interoperability Program
JTIDS	Joint Tactical Information Distribution System
J-UCAS	Joint Unmanned Combat Air System
LOS	line-of-sight
LRE	launch and recovery element
LTA	lighter-than-air
MC2A	Multi-Sensor Command and Control Aircraft
MCE	mission control element
MILCON	military construction

MP-RTIP	Multi-Platform Radar Technology Insertion Program
MTI	Moving Target Indicator
MQT	mission qualification training
NATO	North Atlantic Treaty Organization
NRT	near-real-time
NSS	National Security Strategy
NTISR	non-traditional intelligence, surveillance and reconnaissance
OEF	Operation Enduring Freedom
OIF	Operation Iraqi Freedom
O&M	Operations and Maintenance
PCS	permanent change of station
PEM	Project Element Monitor
PID	Positive Identification
PME	Prime Mission Equipment
POM	Program Objective Memorandum
RAF	Royal Air Force
R&D	research and development
RPA	Remotely Piloted Aircraft
RCS	radar cross section
ROVER	remote operations video enhanced receiver
SAR	synthetic aperture radar
SATCOM	satellite communications
SBR	space-based radar
SCDL	surveillance and control data link
SIF	Selected Identification Feature
SIGINT	signals intelligence
SIPRNET	Secret Internet Protocol Network
TDL	Tactical Data Link
TEL	transporter erector launcher
TLA	target location accuracy
TST	time sensitive targeting
UHF	Ultra High Frequency
UK	United Kingdom
USSTRATCOM	United States Strategic Command
VADER	Vehicle and Dismount Exploitation Radar
VHF	Very High Frequency
WAS	wide area surveillance

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